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SEPTEMBER 1984

THIS CONTRACTOR REPORT WAS PREPARED AS BACKGROUND INFORMATION FOR OTA'S ONGOING ASSESSMENT: PREVENTING ILLNESS AND INJURY IN THE WORKPLACE. AS A CONTRACTOR'S REPORT TO OTA, THIS REPORT HAS BEEN NEITHER REVIEWED NOR APPROVED BY THE TECHNOLOGY ASSESSMENT BOARD.

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Preface

This volume is a paper, "Potential Office Hazards and Controls," written for OTA to assist in preparation of the report *Preventing Illness and Injury in the Workplace*. Findings and conclusions made by the authors of the paper, Robert Arndt, Ph.D. and Larry Chapman, M.S., Department of Preventive Medicine, University of Wisconsin, Madison, Wisconsin, are theirs and not necessarily OTA's. This paper may prove valuable for readers needing more detailed or specific information than could be accommodated in the final assessment report, and it is being made available for such purposes.

This paper discusses office worker exposure to: indoor air pollution in tightly insulated buildings; potentially harmful psychological stress from poorly designed jobs; and potentially harmful physical stress from poorly designed machines and work stations. While these problems are non-life threatening or shortening, some are potentially disabling, often cause unnecessary discomfort, and can be excessively costly in terms of lost work-days. Various controls for these hazards are considered and evaluated.

This study, together with research in other areas was used in preparation of OTA's assessment report, to be delivered to Congress early in the winter of 1984-1985. In addition, other related OTA assessment are underway: *Information and Communication Technologies in the Office*, *Reproductive Hazards in the Workplace*, and *Technology and Structural Unemployment: Retraining Adult Displaced Workers*. Additional information on tightly insulated buildings may be found in the OTA reports, *Energy Efficiency of Buildings in Cities* and *Residential Energy Conservation*.

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EXECUTIVE SUMMARY

Office workers are expressing more and more concern over potential and perceived hazards including stress, air quality, ergonomic problems, temperature, noise, and radiation. Worker advocacy groups, labor unions and the popular press have been responsible for much of this increased level of awareness concerning potential office hazards.

The increasing numbers of complaints about musculoskeletal and visual problems and stress have forced many employers to seek methods for controlling office hazards. The introduction of new office technologies, in particular the video display terminal (VDT), is probably responsible more than anything else, for the increased attention given to office hazards.

1. Addressing the present concerns of office workers requires the acceptance of a broad definition of occupational health and safety which recognizes as hazards, not only those conditions which can cause physical impairment, but also those which can have an adverse effect upon mental and physical well-being.
2. A review of existing research indicates that there is very little data available which can be used to accurately assess either the number of individuals exposed to various alleged hazards or the adverse health effects of actual exposures. Much of the available information is based upon anecdotal observations or case studies at specific worksites. While more research is available related to the use of VDTs than any other type of office work, even this data is of somewhat limited value due to methodological problems inherent in certain studies. Assessment of risk is further complicated by the lack of objective information concerning exposures levels.

Subjective reports from individuals must generally be relied upon. Many studies do not distinguish between exposure and effects. Finally, the nature of many of the adverse outcomes are not easily measurable. Most complaints of health effects do not lend themselves easily to medical assessment, and consequently, self-reported symptoms are the only source of data. There are few studies available which relate long term low-level office exposures to adverse health effects.

3. Intensive visual demands involved in many office jobs have given rise to frequent complaints of discomfort, fatigue, irritation and strain. In many cases, failure to give adequate attention to correct lighting conditions has exacerbated visual problems. Problems seem to be greater in jobs involving the use of VDTs. Poor quality displays in some cases, and lack of consideration of special lighting requirements for VDTs in others, are likely causes of the higher incidence of problems in many VDT jobs.

4. Repetitive tasks, constrained working positions, inadequate rest, and poorly designed workstations and chairs have led to a variety of musculoskeletal complaints. While some studies have suggested that these problems are more frequent among VDT operators, it appears that job demands and working positions are more important than whether a VDT is being used. The higher frequency of complaints observed in some cases among VDT operators may be due in part to the fact that VDT jobs in many cases tend to be more repetitive.

5. Improper ventilation in offices has made complaints about stuffy offices commonplace. There has also been an increasing number of

episodes of acute affects due to air contaminants such as micro-organisms, gases, vapors and dusts. While there is a lack of data available concerning the number of people exposed to poor air quality, studies have indicated that exposure levels are generally low. At the same time, it is evident that very low exposure levels are capable of producing complaints and adverse health effects. Allergic responses, sensitization and synergistic effects may account for some of the acute responses which have been observed in certain cases. The effects of long term low-level exposures are in many cases unknown. Energy conservation measures, including sealing of buildings and reductions in ventilation, have exacerbated problems in some cases.

6. Complaints concerning improper temperature are probably the most common of any heard from office workers. At the same time, there is no evidence to indicate that the expressed discomfort is associated with any serious health effects. Thus, temperature complaints must be considered primarily as a source of discomfort or possibly as a source of stress. Some of these problems may be traced directly to conscious efforts to conserve energy and can thereby be attributed to policy decisions. At the same time, it is evident that many problems are due to heating and ventilation systems which do not perform adequately; or a variety of other factors which are generally not given adequate consideration including thermal effects of windows, equipment, and air movement.

7. Noise problems in offices are seldom of sufficient magnitude to constitute a hearing loss risk. Generally office noise acts as a source of irritation, discomfort or distraction, with conversation

being one of the most common sources. In some cases, certain types of equipment may be responsible for high noise levels which could present a risk of hearing loss, and also serve as an important source of irritation and stress.

8. Reports of cataracts and clusters of reproductive problems among VDT operators have generated fear that VDTs emit harmful levels of radiation. There is, however, no scientific evidence currently available which specifically links either of these problems with VDTs, although very few studies have actually addressed the issue. Radiation emissions have consistently been found to be below applicable safety standards. Despite assurances by industry and the federal government, concern continues to be raised, however, since there are no existing standards for some regions of the non-ionizing electromagnetic spectrum within which VDT emissions occur. There also exists the fear that current safety standards may not provide sufficient protection. Whether or not there is a hazard, it is clearly evident that a high level of concern and fear exists among VDT operators, especially those who are pregnant.

9. A variety of working conditions including environmental, job design, organizational and psychosocial factors have been identified as potential sources of stress in offices. While the relationship between stress and disease is generally accepted, there are few studies which have demonstrated physical outcomes of long term exposure to stressful working conditions in offices. Most stress-related complaints are reflected in attitudinal and emotional feelings about work, or self-reported psychosomatic problems. Stressful working conditions may also contribute to increased job dissatisfaction, absenteeism and turnover.

10. Several of the hazards which may be present in office work have the potential to cause serious physical harm, especially when exposures are repeated and long term. The majority of complaints, however, concern immediate effects in the form of discomfort, irritation, pain, dissatisfaction and emotional responses beyond what might be expected in a normal workplace. Chronic exposure leads to a deterioration of general health and well-being. It is clear that any public policy or strategy for controlling office hazards must address these complaints as well as more serious impairments.

11. Control methods exist for all of the recognized office hazards, but are not applied for a number of reasons. In some cases, the failure to abate hazards can be attributed to a lack of knowledge (concerning both causes and controls) among those responsible for making decisions including managers, manufacturers, and professionals. In other cases, problems persist because there is no incentive to make changes. Discomfort, pain, irritation and dissatisfaction generally cannot be evaluated in terms of direct costs to employers and control methods often appear financially counter productive. Furthermore, the economic costs of absenteeism, turnover and reduced performance which might be associated with poor working conditions have not been demonstrated to a sufficient degree to provide an incentive for change. While legislative mandates provide an incentive, many of the hazards associated with office work do not lend themselves easily to such methods. Traditional standards setting approaches do not appear to offer a feasible alternative at this time.

12. There currently exists a definite need to generate information concerning the nature and extent of hazardous exposures in offices. In addition, the efficacy of implementing different abatement methods must be convincingly demonstrated.

13. Dissemination of accurate and usable information and systematic training of employees, employers, and professionals responsible for the design of office environments and office work are obvious necessities under any circumstances, and especially in view of the changes which will continue to occur in office work under the inevitably growing influence of micro-electronic technologies. This may be the most important means by which government can take an immediate and active role in addressing office working conditions.

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CHAPTER 1

INTRODUCTION

Background

The office has traditionally been considered as a relatively clean, safe and healthy place to work. Relatively speaking this is supported by data based upon established criteria for measuring health and safety risks, such as accidents, fatalities and occupational diseases. However, the recent concerns being voiced by office workers suggest that different measurement criteria might lead to a different conclusion about the environments and working conditions of office workers. These concerns which are expressed in terms of discomfort, irritation, anxiety, job dissatisfaction and diminished well-being are not reflected to any degree in currently available statistics from organizations such as the National Safety Council or the Bureau of Labor Statistics. More appropriate outcome measures might include sick leave, absenteeism and turnover rates.

The increasing awareness and concern related to health and safety in the office can be attributed to three concurrent public health issues: (1) stress; (2) air pollution; and (3) VDT-related complaints.

The magnitude of concern about stress is reflected in the proliferation of popular press articles, seminars, workshops and stress coping or stress management techniques. The American Academy of Family Physicians estimated that as many as two-thirds of all office visits to physicians are prompted by stress-related symptoms (Time, 1983). A 1977 NIOSH study (Colligan et al., 1977) which reported that secretaries, office managers, and manager-administrators were among the 12 high stress-related disease incidence occupations (out of 130 studied); and the report from The Framingham Heart Study that coronary heart disease rates were almost twice as great among women holding clerical jobs as housewives (Haynes and Feinleib, 1980), have brought the issue of job stress in the office to the forefront.

The general public health concern over air quality, along with energy conservation measures implemented in the late 1970s, have given rise to a variety of questions and complaints about indoor air quality. While a number of episodes of health-related disorders have surfaced, the most frequent complaints relate to the so called "stuffy office syndrome."

Perhaps the single most important underlying influence in raising the health and safety consciousness of office workers has been the introduction of the video display terminal into the office. Early European reports indicated that those who worked at VDTs reported a high incidence of visual, musculoskeletal and stress related disorders. These health concerns were expanded in the U.S. to include possible radiation effects in the late 1970s when reports of alleged radiation related cataracts and adverse reproductive outcomes began to surface. While the sheer magnitude of the number of workers utilizing VDTs no doubt accounts for much of the widespread concern currently being witnessed, the influence of the public media, organized labor, and public interest groups cannot be denied. This influence is reflected in the fact that legislation concerning the use of VDTs has been proposed in at least eight states.

Office Work in the United States

The office environment has been broadly defined as "the workplace of white collar workers, including managers and administrators, professional and technical personnel, salespersons, and clerical workers" (Saffady, 1981, p. 1). Thus, the terms "white collar worker" and "office worker" are often used interchangeably. For the purpose of this report, it is useful to examine further and distinguish between different types of white collar workers and different uses of offices since some of the subsequent discussion on office automation, risk factors and control techniques is highly dependent upon these distinctions.

According to BLS statistics, approximately 51.4 million of the 102 million member U.S. work force were classified as white collar workers in 1980 (Carey, 1981). (See Figure 1-1 for summary.) The white collar work force was further divided into four categories:

Professional and technical	16.4 million
Managers and administrators	9.4 million
Sales workers	6.8 million
Clerical workers	18.9 million

Examination of occupations within these groups reveals that certain categories can be established based upon the type of office use (e.g. processing information vs. providing services) and the amount of office use (intensive vs. incidental). In other cases, there are significant numbers of white collar workers who do not actually work in offices. The major occupations which can be distinguished on this basis are described below for each of the white-collar categories. Except when indicated, occupational employment figures are based upon U.S. Census Bureau (1983) data.

Professional and Technical Workers

Most offices in this category might be referred to as staff offices. Some serve functions such as planning, accounting and marketing while others

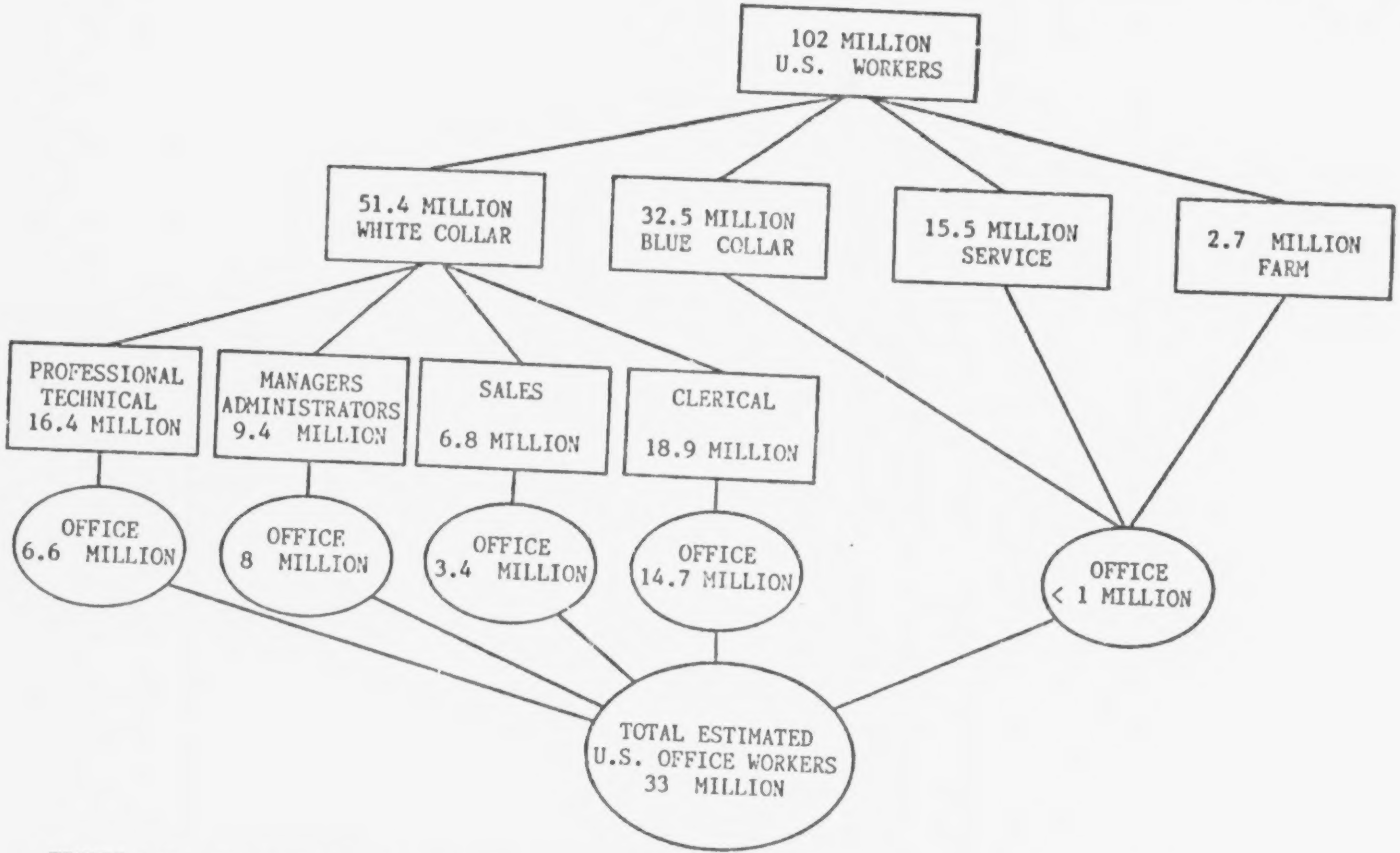

FIGURE 1-1. Estimated number of U.S. workers who work primarily in offices. (See text for explanation of estimation methods.)

are oriented toward professional categories such as engineering and law (Panko, 1981). Table 1-1 lists the major occupations and their prevalence among the professional and technical category of white collar workers. As can be seen from Table 1-1, a number of office types and uses would have to be grouped together if all these occupations were to be considered simply as office workers. The most notable are health care professionals and technicians which account for 19% of the total. These individuals are primarily performing a service within their offices rather than carrying out information processing similar to a bank or insurance company. The second major category of professionals includes preschool, primary and secondary school teachers and accounts for 19% of the professional-technical work force. While some of these may have offices, their use is incidental to the primary function of their jobs. Other categories of professional workers which include a significant number of varied or limited office uses include writers, artists and entertainers; religious, social and recreational workers; as well as a variety of occupations included in the category listed as "other" (e.g. airline pilots, air traffic controllers, etc.). Based upon these considerations, it is estimated that approximately 40% of the 16.4 million professional and technical workers actually spend a substantial portion of their time in office environments carrying out information related activities.

Managers and Administrators

Most workers in this category work in offices that manage organizational units, often referred to as executive offices. The largest single category of occupations which probably does not make substantial use of an office includes managers of restaurants, cafes, and bars (5-6% of all managers and administrators).

TABLE 1-1

Occupational Classification of Professional and Technical Workers

Occupation	Number Employed (1000)	Percentage of all Professional Technical
Engineers, scientists and engineering technicians	3,303	20
Accountants	1,126	7
Health care (physicians, dentists, nurses, therapists, technicians)	3,125	19
Teachers -		
College and University	585	4
Other	3,197	19
Writers, artists, and entertainers	1,388*	8*
Religious workers, counselors, social and recreational workers	1,036	6
Computer specialists	627	4
Others	2,100	13
TOTAL	16,420	100%

*Includes certain office jobs (e.g. newspaper writers).

A substantial number of managers also hold positions in retail sales. Combined with a variety of other occupations, it is estimated that at least 15% of the workers classified as managers and administrators do not spend a significant amount of time in an office.

Sales Workers

This category of occupations includes sales clerks, peddlers, and traveling salesmen; none of whom work primarily in an office. Sales clerks alone account for 43% of all sales workers. It is, therefore, estimated that a maximum of 50% of all sales workers are actually employed in offices.

Clerical Workers

Table 1-2 lists the major occupations included in the clerical category. Clerical offices deal mostly with the processing of routine information (Panko, 1981). It is this type of office that is most often referred to when the terminology "office worker" is used. Traditional office management courses are generally referring to clerical workers when they discuss office workers, and most standard texts on office administration deal almost exclusively with clerical offices (Keeling et al., 1978).

This category also includes a variety of other occupations which do not fit the traditional concept of a clerical office, however, including telephone operators, bank tellers, dispatchers, etc.

The largest identified occupations unlikely to work in offices include: storekeepers (3%), shipping and receiving clerks (3%), postal employees (3%), counter clerks (2%) and teachers' aides (2%). In addition, a substantial portion of those classified as cashiers (9%) might be included as well as a number of those in the "other" category (e.g. stock clerks, meter readers,

TABLE 1-2

Occupational Classification of Clerical Workers

Occupation	Number Employed (1000)	Percent of Total Clerical Work force
Secretaries	3917	21
Bookkeepers	1961	10
Cashiers	1660	9
Typists	1031	5
Office machine operators	966	5
Office clerks	838	4
Insurance claims	731	4
Receptionists	675	4
Bank tellers	569	3
Storekeepers	528	3
Shipping and receiving clerks	525	3
Mail carriers/postal clerks	511	3
Teachers' aides	400	2
Counter clerks	360	2
Telephone operators	308	2
Clerical supervisors	250	1
Stenographers	74	--
Other (e.g. dispatchers, library assistants, messengers, etc.)	3496	19
TOTAL	18,900	

library assistants, desk clerks). It is, therefore, estimated that approximately 78% of all clerical workers are employed in offices.

It should also be noted that a small number of blue collar workers, service workers and farm workers do work in offices.

It is estimated that approximately 33 million (32%) of those employed in 1980 worked in offices (Panko, 1981, estimated 40% but included certain health care occupations; other estimates have been as low as 20% [Zisman, 1978; Sadleir, 1980]). While some major shifts in occupational categories have been occurring in the 70s and 80s (described below), these would not appreciably affect the applicability of this estimate to 1983 employment. Based upon the above considerations, it is believed that the numbers and percentages of workers in the major occupational categories listed in Table 1-3 provide a reasonable estimate of the number of workers potentially affected by the type of risk factors discussed in this report.

Employment Projections and Shifts

Four factors relating to projected changes in the nature and distribution of the office work force are considered below: growth rates, occupational distributions, sex distribution, and age distribution.

Growth Rates

The labor force is expected to increase by about 17-25% during the 80s (Nardone, 1982). All major occupational groups, except farming, should continue to grow, with the largest gains being registered among service workers and white collar workers.

TABLE 1-3

Estimated Number of Office Workers in the United States

Major categories of workers	Number in work force	Percent of total office workers
White Collar		
Professional, technical	6.6 million	20%
Managers, administrators	8.0 million	24%
Sales workers	3.4 million	10%
Clerical workers	14.7 million	45%
Blue collar, service, farm	.3 million	1%
TOTAL	33 million	

Occupations

The number of professional and technical workers is expected to increase at a rate slightly higher than that for all occupations combined. The largest gains will, however, be in the health-related professions. Sales workers and clerical workers will also increase in numbers slightly above average until 1990. Management and administrative employment is expected to increase at a rate slower than other occupational groups. In terms of new white collar openings through 1990, clerical jobs are projected to increase by the greatest numbers. The introduction of new technology into offices will lead to high growth rates in computer related jobs such as systems analysts, computer operators, programmers and peripheral EDP equipment operators (Carey, 1981; Howard and Rothstein, 1981). There are conflicting opinions, however, about the effects of office automation on clerical workers. Since a major emphasis is increasing productivity, the number of office workers has to decrease or the amount of work accomplished must increase if productivity gains are to be realized. It is generally believed that automation will not substantially affect the number of jobs available to professional and technical workers but may eliminate some middle management positions (Business Week, 1983).

Age Distribution

Substantial shifts in the age distribution of the available work force are expected to occur during the next two decades. Projections are described in Table 1-4 (from Wolfbein, 1982).

The work force of the 80s will undergo a shift toward more experienced workers as more people enter the 25 to 44 age group. This group accounted for 40% of the work force in 1970, 46% in 1980, and will represent over 54% of the work force in 1990. Since middle management is usually drawn from this group,

TABLE 1-4

Age Distribution of U.S. Labor Force*

Age	Percent of Total Work Force	
	1980	1990
16-24	23.5	18.5
25-34	26.9	28.6
35-44	19.3	25.5
45-54	16.2	15.8
55-64	11.2	9.1
65+	2.9	2.5

*Based upon Wolfbein, 1982

there should be an increasing availability of qualified individuals and decreased opportunities for career advancement.

The decreased opportunities could be offset to some degree by the reduction of more senior workers, especially over 55 (17.5% in 1970 and 11.6% in 1990). This trend could lead to a greater consciousness of job security (Mills, 1979).

There will also be a reduction in available young workers for entry level jobs. This fact along with a higher educational level and potentially different values among young workers has led some to believe that there may be a labor shortage for entry level jobs, especially if they are simplified, repetitive and boring jobs with little opportunity for advancement (Spencer and Long, 1983).

Sex Distribution

Women now constitute about 43% of the total labor force. This number has grown from 38% in 1972, and is expected to continue to rise in the future. Almost 54% of all white collar workers are women, with the largest proportions occurring in clerical jobs, and the lowest in managerial and administrative jobs. Table 1-5 indicates the percentages of women in selected jobs and the percent increase over 1972 levels. Some of the largest gains for women workers between 1972 and 1981 were realized in the following occupations: accountants, personnel and labor relations, bank officials and finance managers, office managers and clerical supervisors. The estimated percentages of women actually working in offices are listed in Table 1-6. Approximately 53% of all office workers are therefore estimated to be women, with the highest proportion (85%) occurring in clerical work. The proportion of women

TABLE 1-5

Number and Growth Rates of Women in Selected Occupations

Occupation	Percentage of women 1981	Percentage Increase Since 1972
Professional/technical	44.6	5.3
Accountants	38.5	26.8
Computer specialists	27.1	10.3
Engineers	4.4	3.6
Personnel/labor relations	49.9	18.9
College and university professors	35.2	7.2
Technicians	16.8	9.7
Managers/administrators	27.5	9.9
Bank officials and financial managers	37.5	18.5
Health administrators	49.8	3.2
Managers, supervisors	50.9	8.3
Office managers	70.6	28.7
Sales	45.4	3.8
Clerical	80.5	4.9
Bank tellers	93.5	6.0
Bookkeepers	91.1	3.2
Clerical supervisors	70.8	13.0
Office machine operators	73.6	2.2
Secretaries	99.1	--
Stenographers	90.4	5.3
Telephone operators	92.9	3.8
Typists	96.3	--

TABLE 1-6

Estimated Percentage of Women in the Office Work Force

Office occupational groups	% Female
All white collar office jobs	53%
Professional and technical	25%
Manager, administrator	25%
Sales workers	30%
Clerical	85%

in the work force is expected to continue to increase and will account for most of the growth in employment during the 80s.

Office Work and New Technology

The traditional office has been subjected to an accelerating trend toward increasing technological change. This trend toward the electronic storage and transmission of information has led to what is referred to as the "office of the future," the "paperless office" or "office automation." It began with the introduction of the electric typewriter in the mid-sixties. Copiers improved tremendously during this period and offices began utilizing computer assisted microfilm retrieval. While minicomputers had been available for some time, high costs prevented widespread use until the early 70s.

The 1970s saw further advances, especially in the area of word processing. The more widespread use of minicomputers and the introduction of microcomputers in the late 70s led to decentralized uses of computers. Micrographics and reprographics were more extensively tied in with computers. In addition, electronic communications technologies, including electronic mail, voice messaging, teleconferencing, and videoconferencing were introduced. Current office technology is focusing on creating an "electronic workstation" which allows the user to perform all functions previously carried out using paper, and tie individual resources into a single network.

Other technological tools currently being developed or improved include: voice communication devices for recognizing and synthesizing speech, electronic speech compressors, "intelligent telephones," optical character readers, and electronic blackboards. In addition, many of these are being adapted for what is referred to as "telecommuting," by developing a portable office. The rapid development of these technologies can be attributed to the recent advances made in the field of microelectronics.

Motivating Forces in the Application of New Office Technologies

The most often cited motivating force in the application of new technology is the desire to increase productivity. Concerns over the apparent lack of improvement in white collar productivity have led many businesses to invest in office technology. There are two ways in which such tools can be applied in an attempt to accomplish this end: (1) cost displacement systems, and (2) value added systems. Cost displacement systems are intended to reduce unit costs by improving the efficiency of routine tasks or by eliminating them. The most common applications have been word processing and dictation to improve typing efficiency. Records management and administrative filing are two other applications. Cost displacement systems are usually the first step for most businesses and are aimed primarily at improving the productivity of secretarial and clerical personnel.

Value-added systems are those which increase the effectiveness of personnel and thereby enable them to perform additional functions. These systems include electronic mail, teleconferencing, management information, and decision support systems; and are directed primarily toward managers and professionals.

A second force contributing to the increased use of office technologies is their ready availability. The costs of electronic equipment have dropped considerably while labor costs continue to rise. It is, therefore, easier to justify the costs of new equipment which is promised to reduce manpower needs. Vendors are highly visible at trade shows and in professional journals and magazines, publicizing the message that office automation offers the solution to many problems. A third factor, which could be a cause or an effect of office technology applications, is increased control over work activities.

Potential Effects of Office Automation

New technologies can be used in offices in a variety of ways. Early advances in office technology such as electric typewriters and copying machines tended to mechanize certain office tasks. That is, they provided tools that workers could use to do their jobs better. However, some of these tools, beginning perhaps with the use of computers to replace card punch and accounting machines, actually replace human labor with electronic labor and, thereby, represent automation of office tasks. For example, word processors may perform the tasks of retyping and checking for spelling errors. Voice recognition systems may eventually replace the steno pool.

This definition of office automation has been expanded considerably, however, to include the use of virtually all types of technological changes. For example, Olson and Lucas (1982) indicate that "office automation" refers to "the use of integrated computer and communication systems to support administrative procedures..."; and Panko (1981) contends that "office automation ... embraces any tool to enhance the productivity or performance of office workers." Saffady (1981) believes that "Office automation involves the application of technology to the creation, storage, manipulation, retrieval, reproduction, and dissemination of information in the office environment." Clearly the use of some of the tools of office technology do not fit the traditional definition of automation. For example, teleconferencing does not directly replace human labor in the office. Some of these tools augment office activities in that they allow workers to perform new tasks or perform old tasks in better ways.

These distinctions are significant in that one of the major concerns of many groups, and in particular labor unions, is that workers will be displaced as "office automation" increases (Kirchner, 1982). Any projections concerning the impact of office automation on employment are problematic. The greatest concerns have been expressed in European countries where predictions are very pessimistic (Marsh, 1982; GAO, 1982). A U.S. government study concluded that most people agreed that some job loss would be experienced in the short run, but that long range projections were impossible to make (GAO, 1982). A report prepared for the International Labour Office indicated that microelectronics technology had not yet produced widespread displacement of workers, possibly because of a delayed rate of diffusion into the office (Wernecke, 198[illegible]).

It is apparent that certain occupations have already been hit by automation. Examples include typesetters and telephone operators and stenographers. The number of telephone operators declined by 75,000 (-19.4%) and the number of stenographers declined by 61,000 (49%) between 1972 and 1980. At the same time total employment was increasing by 19% (Leon, 1982). Future impact has been forecast for middle managers. This impact may occur in the form of displacement, deskilling or difficulty in finding work in a chosen field, often with attendant losses in earnings. While it is obvious that in certain cases jobs are eliminated, the number of white collar jobs has continued to increase at the clerical, professional, technical and managerial levels. BLS projections based upon continued growth of the economy suggest that more jobs will continue to be available through 1990 (Carey, 1981). Examination of these optimistic projections do, however, indicate wide variations in the relative rates of growth for different occupations. There is considerable debate about these projections, although more concern appears to be directed toward blue collar jobs.

The increase in the number of jobs available may not solve the problems of individual worker without some adverse psychological, social and economic effects. While there is little evidence to suggest that being displaced by computers is a serious concern of many office workers, labor unions are tending to seek job security agreements more frequently. For example, the recently negotiated agreement between Bell System companies and the Communications Workers of America (CWA) includes extensive contract language concerning training, retraining, income protection and early retirement. Thus, while craft employees and operators may be displaced from their current jobs, many will continue to work for the same employer, a trend which has been evident in the Bell System for years.

Another unique factor in low level clerical occupations which may attenuate the effects of automation on individuals is the high turnover rate. That is, high turnover rates may reduce the risk of job loss for individuals who wish to continue in the same occupation.

Office automation systems and other technologies can also affect workers by changing the organizations they work in, the work environment and the nature of the job.

Organizational Effects. New technologies allow a choice between centralized and decentralized organizations. Since electronic networks allow communications between individuals at the same level and at different levels, certain positions, in particular middle management, may be redundant. In many cases, supervisors simply become enforcers with little control over work methods and decisions. Control over production may be shifted to programmers and higher management, making it more difficult for workers to communicate.

Face-to-face contact with other workers tends to be reduced at all occupational levels. A considerable amount of attention has recently been given to the potential for remote work (either in satellite work centers or the home) for clerical, professional, and managerial workers. While the advantages of reduced travel, flexible working hours and convenience for working parents and the handicapped are often mentioned, career opportunities and social contacts may also be diminished.

Physical Environment Effects. The major physical changes which occur in the work environment are related to the use of video display terminals. Studies have clearly demonstrated that a variety of ergonomic problems associated with the design of the VDT itself, lighting, and workstation design occur when these new tools of office technology are introduced.

Effects on Jobs. While it is argued that new office technologies can serve to increase job satisfaction by increasing task variety, skill requirements and feedback, this does not appear to be the case in all situations. Historically, technological innovations have been applied most often at the bottom of the hierarchy of jobs. At the clerical level, technologies may provide tools to perform work in an easier more efficient way, but the free time which results is filled with an increased volume of work. As a result, jobs become more simplified, repetitive and unsatisfying. Computer technology has seldom been used to upgrade clerical jobs. There is a deliberate endeavor to maximize efficiency and output, and there is greater pressure to work quickly and accurately, often at a pace set by a machine. Monitoring of work output becomes more common and is even considered essential by some experts in order to maximize efficient use of equipment (Kish, 1982; Meyer, 1980; Cyr, 1979).

The effects on professional, technical and managerial workers may be quite different since an alternate philosophy is generally applied. By providing the work force with tools which relieve the worker of routine tasks or assist in the performance of present tasks, it is reasoned that more time will be available for more creative work. Performance will improve and the worker will also be more satisfied.

The potential impact of reduced social contact due to electronic communication capabilities and "telecommuting" is difficult to assess.

The Impact of The Video Display Terminal

The video display terminal is the tool which acts as the interface between the worker and virtually all of the other office technologies described above. While optical character readers are already available and voice recognition and speech synthesizers are under development, the VDT will continue to be the instrument for communicating with office technologies throughout the present decade.

The VDT is the symbol of office automation to most workers and is almost synonymous with computers. Consequently, concerns and dissatisfaction with office technology are often directed toward VDTs. For example, workers voicing complaints about VDTs will often include response delays, "unfriendly systems" and excessive monitoring.

Questions about VDTs are a central issue for office workers (especially clerical workers) concerned about office safety and health. Some of the questions raised in relation to VDTs and associated technologies include:

- Do VDTs themselves present a hazard (radiation, visual problems, rashes, etc.)?
- Are VDTs properly designed?

- Do VDTs require special environmental considerations (e.g. lighting, workstations)?
- Do VDTs and associated technologies actually change the mental and physical demands of jobs?
- Do VDTs and associated technologies change the nature of work and organizations (e.g. control, social interaction, job security, career development, etc.)?

The significance of the concern about VDTs is affected by the number currently in use and the number that will eventually be in use. The potential impact of concerns about video display terminals must also be considered in terms of their uses in other settings. Microcomputers or personal computers are becoming more prevalent in occupations outside of the office. VDTs are already used in many of the service occupations, in industry, and even on farms. Finally, the impact of VDTs and technology must be considered in terms of their educational, recreational and consumer uses.

Microelectronics Applications

Clerical workers utilize video display terminals primarily for word processing, data entry and retrieval. Word processing may be carried out on a stand alone unit or on a microcomputer. Other activities are carried out on terminals linked to computers (or interactive VDTs). Estimates of the current numbers of interactive displays range from 7.1 (Dataquest, 1983) to 9.8 million (International Data Corporation, 1983). These estimates do not include stand alone units (i.e. word processors, personal computers, games, cash registers) or special use terminals (i.e. bank tellers, airline reservations, cashier systems). Dataquest (1983) projects that the number will reach 25 million by 1990. These figures do include programmer uses, management information systems, and data processing uses.

Personal computers (usually microprocessors) may or may not be included in the above estimates depending upon their use. The current number of personal computers used in business applications is estimated to be 2.6 million units and is expected to grow to 15-18 million by 1990 (Blundell, 1982; 1983). An additional 1 million units are used in the home (8.6 million by 1990) and .4 million units are used in schools (3 million by 1990), according to one source (Blundell, 1982).

The number of word processors already in use in 1979 was estimated to be 300,000 (Thoryn, 1979) and is certainly much higher today. One source estimates that word processors are currently used in 31% of all offices (NOPA, 1983). Table 1-7 provides one estimate of how microcomputers are used in large organizations. As can be seen, the largest increase in use is projected to occur in word processing applications.

Since these estimates of different uses overlap and, in other cases, do not include specific uses or multiple users, it is difficult to determine how many individuals are actually working at terminals or the number affected by automation. One management consultant estimated that 38 million white collar jobs may eventually be affected by automation (including 9 million managers, 14 million professionals, 5 million secretaries and supervisors and 10 million clerical workers), while a major manufacturer has suggested that 20 to 30 million will be affected by 1990 (Levitan and Johnson, 1982).

While most scholars and manufacturers are optimistic that normal economic growth will counteract job displacement, it is clear that work will be restructured, many skills will be devalued and workers (especially clericals and middle managers) will find it necessary to adjust. Employers will find it necessary to retrain large numbers of workers or seek qualified workers outside the organization, and labor organizations will expand their efforts to obtain security clauses in contracts.

TABLE 1-7*

Typical Uses of Microcomputers

	Percent of Total Applications	
	1982	1992
Dedicated to specific package	37	23
Word processing	7	44
Never used successfully	9	12
Departmental use	14	9
Engineering and scientific	21	9
Terminals	4	--
Payroll and accounting	7	3

*Adapted from International Resource Development, Inc. (Etelman, 1982)

CHAPTER 2

POTENTIAL OFFICE HAZARDS

Introduction

A variety of conditions related to office environments and work have been posed as potential health hazards by different interested parties. In this chapter, each of these problem areas and concerns will be addressed. These problems cover a wide range of environmental and work design issues, as well as a variety of different types of health effects which, for the most part, have received relatively little consideration from an occupational health and safety public policy viewpoint in this country. It is, therefore, necessary to re-examine the basic issue of what constitutes a health or safety hazard in order to provide a basic context within which each of these factors can be considered. In traditional health and safety terminology, a hazard is defined as a "potent~~ial s~~ource of harmful contact" (Bird, 1973) or a "condition with the potential of causing injury" (Hammer, 1976). These definitions imply that the condition is capable of causing harm and that contact is possible. The capability of a chemical to cause disease is referred to as its toxicity. A toxic chemical becomes a hazard when it exists in sufficient amounts to cause harm. The potential adverse effects of exposure to a hazard are also affected by the duration of exposure.

Given this definition of a hazard, it is then necessary to establish what constitutes harm or adverse health effects. There is little doubt that physical injuries and disease are adverse health effects. As will, however, become evident in the subsequent discussion of potential health hazards in offices, such physical impairments are often difficult to identify. At the same time there are a variety of other indicators of adverse health effects including pain and psychological distress. In the broadest sense, the definition of health can be expanded to include the absence of irritation and discomfort. Thus, Ashford (1976) described occupational safety and health as encompassing "not only the problems of preventing physical disease and injury, stress, psychological disorders and work alienation, but also the promotion of mental well-being and job satisfaction" (p. 45). Occupational health has been defined by the International Labour Organization and the World Health Organization (1963) as " .. the promotion and maintenance of the highest degree of physical, mental, and social well-being of workers in all occupations, ..." (p. 4).

The definition of adverse health effects should then provide the basis upon which permissible exposure levels and control technologies can be established. It should be kept in mind, however, that the establishment of a permissible exposure level is also affected by a variety of other considerations including the possibility of synergistic effects, aggravation of pre-existing conditions, hypersusceptibility and potential long term effects, all of which may occur at lower levels. There is a tendency, therefore, to provide some margin of safety. On the other hand, public health decisions are also mediated by a number of non-health related considerations including socioeconomic and political factors. These will be discussed further in the sections on control strategies.

In order to accurately assess health and safety problems in the office environment, care must be taken to distinguish between factors which constitute hazards as described above, and those which are referred to as risk factors by epidemiologists. Hazard implies a causal relationship while risk factor implies only a predictive relationship. This distinction is important for two reasons. First, much of the research related to office health and safety is based upon surveys in which correlations are established between adverse health outcomes and various aspects of the work environment. Secondly, in order to adopt the most appropriate control strategy, causes rather than risk factors should be identified. The most pertinent example in office work concerns the use of video display terminals. As will be shown, a number of studies have reported a higher incidence of visual complaints among VDT operators as compared to traditional office workers.. If the actual cause of the vision complaints can be related to factors such as image quality or screen flicker, then the VDT constitutes a hazard. If the vision complaints arise out of the fact that the VDT task studied involves more intensive and sustained visual work than the comparison task, the VDT represents a risk factor. In the first case, control strategies would be directed toward the design of the equipment and in the second case toward the design of the task.

Summary

If a given factor is, by its nature, capable of causing adverse health effects at levels which may be shown to exist in office environments, it can be judged to constitute a hazard. The two major questions to be examined with respect to each of the factors discussed are: (1) to what extent does the factor exist within the environment and (2) what type of adverse health effects can be associated with the existence of the condition.

In terms of public policy decisions, judgments must ultimately be made by those responsible for the protection of worker health and well-being, based upon the extent to which the condition occurs and the desired level of protection to be afforded to office workers.

Stress

Stress is currently one of the most pervasive health problems in the United States. The American Academy of Family Physicians has suggested that two-thirds of office visits to family doctors are prompted by stress-related symptoms (Time, 1983). Michael Smith, Chief of NIOSH's Motivation and Stress Research Section, recently wrote:

> "Emotional disturbances of an acute, neurotic nature (distress syndrome) are at epidemic proportions in the U.S., according to the latest statistics from the National Institute of Mental Health ... Such disorders accounted for more than 15 percent of the total workers compensation costs in California in 1980 and have steadily grown each year. Today 19 states recognize such emotional disorders as being, potentially, work related and award compensation" (Smith, 1982, page 18).

According to Paul Rosch, Director of the American Institute of Stress, "Stress management has become a multimillion-dollar-a-year business" (Time, 1983). Mental health experts estimated that there were over 130 methods of therapy or techniques for coping with stress in 1979 (Wall Street Journal, 1979), and there are, by some estimates, more than 300 stress-management enterprises offering their services to hospitals, clinics and corporations around the country (Time, 1983). It is clear that problems at work are currently one of the major contributing factors in stress (Cooper and Payne, 1978, 1980).

All types of office workers have been considered as prime targets for potential stress risks. While early studies concentrated on "executive stress" more recently the focus has turned to middle management and clerical workers. A NIOSH study (Colligan et al., 1977) reported that secretaries had the second highest incidence of stress-related diseases of 130 occupations evaluated. Office managers and manager-administrators were also among the 12 "high stress" occupations. Results from the Framingham Heart study indicated that women holding clerical jobs had coronary heart disease rates twice as high as housewives (Haynes and Feinleib, 1980).

The relationship between stress and certain diseases are well-established (e.g. ulcers, coronary heart disease, diabetes and arthritis). In addition, there is a growing body of evidence suggesting that stress affects the body's general resistance to disease, thereby increasing susceptibility to everything from the common cold to cancer. However, in the workplace other measures of stress are necessary, including attitudinal variables such as job dissatisfaction; emotional states such as tension, anxiety, anger, and frustration; somatic complaints such as muscular tension, headaches, and gastrointestinal problems; or behavioral variables such as drinking, smoking, medication use, drug use, and absenteeism. While the relationship between stress and these outcomes are not always clear and unequivocal, it is readily apparent that stress is a major contributing factor. It goes without saying that the costs in terms of both degraded health and well-being and economic burdens are potentially staggering. Based on national samples, stress-related symptoms have been estimated to cost industry $50-75 billion a year in absenteeism, company medical expenses and lost productivity (Time, 1983).

Some of the most frequently described sources of stress for clerical workers include:

- monitoring
- machine pacing
- lack of promotional opportunities
- low pay
- monotonous and repetitive work
- environmental conditions (e.g. temperature, air quality, and ergonomic problems)
- lack of feedback
- underutilization of skills

- production quotas
- lack of participation and control
- overtime
- unsupportive bosses or supervisory problems
- sexual harassment
- conflicts between home and work demands
- piecework

A list such as the one above can be developed simply by asking a group of workers what bothers them. The fact that these conditions are sources of complaints does not, however, indicate the extent of risk associated with clerical jobs. Two questions must be answered. First of all, the frequency and degree to which these conditions exist in the work environment must be determined (exposure); and secondly, the effects which they may have on individuals must be determined. For example, rigid production quotas might be imposed upon 30% of all typists, but only 5% of those exposed may be bothered by them. Nearly 100% of all clerical workers are exposed to low paying jobs but the number bothered by this condition (at least to the point of feeling stress) is much lower.

Thus, a low frequency of reported concerns about lack of promotional opportunities may be accounted for by the fact that promotional opportunities are available, or that many individuals do not have aspirations to be promoted. The prevalence of some of the potential sources of stress listed above have been estimated from surveys of certain occupations. Unfortunately, there have been few national samples which provide clear indications of the pervasiveness of stressful conditions or stress symptoms among office workers.

Effects of Automation

The automation of offices has led to increasing concerns about new or more extreme sources of stress including increased boredom, monotony, job insecurity, job future uncertainties, lack of job control, increased monitoring, job fragmentation, alienation, and job dissatisfaction. Broad statements about the effects of automation are difficult to make. It has been suggested that automation offers the opportunity to eliminate tedious, difficult and boring work. It would appear that in some cases this is indeed possible. However, management has choices concerning how automation will be used. At one extreme, the technology can be introduced under the control of workers to make their jobs easier. At the other extreme, workers are told exactly how to do the work and are closely monitored (scientific management) (e.g. Cyr, 1979; Meyer, 1980). It appears that the former option is being primarily reserved for professional and managerial uses of new technologies.

The most frequent applications of mechanization and automation in offices have, to date, been directed toward clerical jobs (i.e. bookkeepers, secretaries, typists, bank tellers, and insurance workers). It is quite clear that in such applications the principles of scientific management have had a major influence. Scientific management advocates the deskilling and fragmentation of jobs. Tasks should be simple, short-cycled and repetitive, thereby lending themselves to more control by allowing management to specify the "correct method" and closely measure performance (Saffady, 1981). When these principles are followed, clerical jobs which are, in many cases, already simple and repetitive become even more so.

In the words of Frederick Taylor, the "father of scientific management," "under scientific management the 'initiative' of the workmen (that is, their hard work, their good will and their ingenuity) is obtained by absolute uniformity and to a greater extent than is possible under the old system; and in addition to this improvement on the part of men, may the managers assume new burdens, new duties and responsibilities never dreamed of in the past." Taylor also, however, foresaw one of the major obstacles to the application of scientific management "Without the element of stupidity, the method would never work. A pig iron handler shall be so stupid and phlegmatic that he more resembles the ox than any other type ... The man who is mentally alert is entirely unsuited to what would, for him, be the grinding monotony of work of this character" (Taylor, 1911 pp. 36-52). In 1981, only 13% of all male clerical workers and 7% of all female clerical workers had less than a high school education. Twenty-eight percent of the males and 23% of the females had some college and 18% and 9% respectively had college degrees (Bureau of the Census, 1983). In spite of this warning and incongruity, many industrial engineers and management consultants extol the need for such methods if productivity gains and returns on capitol investments are to be realized. Seldom has automation been used to deliberately upgrade clerical jobs.

It is apparent then, that microelectronics technology can be used to make work easier, and many workers (including clericals) report this to be true. However, if the fact that a worker can perform the same amount of work with less energy results in reorganization of work, fragmentation of jobs and increased repetitiveness, decreased job satisfaction and stress can also be expected to increase. Two other aspects of scientific management are also particularly easy to implement in mechanized or automated jobs - monitoring and piecework. The use of a computer makes both very simple since it can accurately record activity on a continuous basis. Many word processors come with features which allow a printout of total task time, number of lines typed and number of keystrokes. Adverse effects of both monitoring and piecework on clerical workers health and well-being have been documented in a number of studies (Cakir et al., 1980; Levi, 1967, 1972; Guttormson and Smith, 1971).

Another potentially stressful aspect of the introduction of new office technologies (which is less easily controlled by management) is the element of machine pacing involved in such jobs. Murphy and Hurrell (1979) have reviewed a variety of studies and found expressions of high job dissatisfaction, tension, underutilization of abilities, frequent health complaints, nervous disorders and a variety of psychosomatic complaints among machine paced workers. While computer control of work pace is of a different nature and degree than that found in many of the jobs from which these results were obtained, it has frequently been observed that machine control of office work pace (especially delays or breakdowns) are a source of worker complaints.

The results of studies comparing VDT and non-VDT work tend to confirm the theory that broad generalizations about the effects of new office technologies should not be made. For example, Sauter et al. (1982) reported that "VDT work did not contribute to psychological distress or job dissatisfaction to any greater extent than non-VDT clerical work" among the group of workers studied. Other studies have reported similar findings (Starr et al., 1982; Sauter et al., 1981; Dainoff et al., 1981; Coe et al., 1980). Thus, the conclusion that VDTs and related technologies do not have to increase psychological stress and job dissatisfaction seems warranted. In fact, a number of studies report some positive aspects and feelings about VDTs (Hunting et al., 1981; Starr et al., 1982; Dainoff et al., 1981; Gunnarsson and Ostberg, 1977; Cakir et al., 1978; Gunnarsson and Soderberg, 1980; Johansson and Aronsson, 1980) especially relating to making certain tasks easier. At the same time, a number of studies have clearly indicated that VDT tasks with certain characteristics are more stressful than both non-VDT and other types of VDT work (Smith et al., 1981; Gunnarsson and Ostberg, 1977; Cakir et al., 1978; Elias et al., 1980; Canadian Labour Congress, 1982). The most frequently mentioned variables were monotony and boredom, monitoring, piecework, loss of control over work pace, technical problems or interruptions, and production quotas.

A NIOSH report (Smith, 1982) concluded, "It appears that job design factors, primarily highly paced work, lack of control and pressures such as deadlines, are more prevalent in some types of VDT work than in others. These factors have been shown to be related to many of the health complaints that are reported by VDT operators and could be linked to serious health disorders" (p. 24).

It is important to reiterate at this point that a finding of no differences between VDT work and non-VDT work may be completely unrelated to the question of how much stress is involved in clerical work. For example, Sauter et al. (1982) after indicating that no differences were found between VDT and non-VDT clerical workers went on to say " ... but stress does predict health complaints, job dissatisfaction and emotional states for both." Examination of some of the other studies indicating no differences reveals similar results. For example, the data reported in the Starr et al. (1982) study indicate that of five dimensions of job satisfaction rated on a scale of zero (dissatisfaction) to 54 (satisfaction), the mean scores for the non-VDT and VDT telephone operators combined were: work in present position (20); present pay (31); chances for promotion (23); supervision (38); and people in present job (37). Since the midpoint of the scale is 27, it must be concluded that either most of those studied are moderately dissatisfied with certain dimension (e.g. work and chances for promotion) or that a significant number are highly dissatisfied. Thus, the conclusion that no differences between automated and non-automated work exist should not be a reason for lack of concern. Analyses of the results of other studies reveal similar findings.

The potential implications for managers and professionals are similar but data is scarce. The few studies involving professional VDT users have not shown any substantial effects. Professionals generally report fewer problems than clericals, however. The lack of information is particularly significant since industry predictions of the future growth of office automation are usually based upon a high rate of future use by professionals and managers. While some of the factors impacting clerical workers (e.g. monotonous and repetitive work, job fragmentation, etc.) are not expected to occur to such a great extent, other factors could. Job displacement (especially for middle managers), machine control, information overload, technical problems, performance monitoring, resistance to change, and ergonomic problems are examples.

Controlling Workplace Stress

There are basically two approaches that can be used to alleviate stress in the workplace. The first involves changing the worker and is embodied in stress coping or stress management techniques. The second approach involves changing the design of the job, organization or environment in order to remove the sources of stress.

Stress Management. By far the most common approach has been the former -- changing the worker. As indicated earlier, there appears to be an endless variety of proposed techniques and methods for coping with stress. Numerous organizations now offer stress management services to industry. While company sponsored stress management programs are most commonly offered for managers, they are in many cases available to professional, technical and clerical workers as well. The principle advantages to organization in using these approaches are: there is no requirement to make any changes at the workplace; management does not have to accept the blame for stress; and they are readily available. From a theoretical standpoint, the principle advantage is that they may be applied (if effective) to any type of stressor, on or off the job. The biggest problem with such approaches is that there is very little evidence that they are effective (Wall Street Journal, 1979). Table 2-1 summarizes the principle advantages and disadvantages of stress management techniques.

Controlling the Source of Stress. The second approach involves reducing or eliminating the source of stress. There are two levels at which control of stressors can occur. First, environmental sources of stress can be controlled (i.e. heat; air quality; uncomfortable chairs, workstations and working positions; noise; and lighting). The environment is adapted to better fit the worker. The second level of control involves reducing or eliminating stressors which arise out of organizational structure, job design or work tasks (e.g. monotonous jobs, lack of control, monitoring, machine pacing, piece rates, opportunity for promotion, etc.). These approaches, when carried out systematically, are variously referred to as "humanization of work," "worker participation," "quality of working life (QWL)," or "job enrichment." An attempt is made to reduce the stress problems by changing work so that it better fits the needs and capacities of workers. Jobs are enlarged or enriched, greater control is given to workers, social interaction is increased, workers are given greater responsibility, boring tasks are made easier through automation, and promotional opportunities are increased. Each of these steps may remove sources of stress from the job.

TABLE 2-1

Advantages and Disadvantages of Alternate Stress Control Methods

STRESS MANAGEMENT

Advantages	Disadvantages
1. Easily available.	1. Needs constant and continuing reinforcement.
2. Assume no blame.	2. Unproven by scientific data.
3. Deals with stress on and off the job.	3. Source of stress remains.
4. No restriction on job design.	4. If worker leaves, investment leaves.
5. Deals with variety of stressors.	5. Costs associated with exhaustion of coping resources.
6. No restriction on product design.	6. Expensive.
	7. Depend upon participation.
	8. May be adverse side effects.

ERGONOMICS - JOB DESIGN

Advantages	Disadvantages
1. Hazard is removed.	1. Requires coordinating at top level management.
2. Changes are permanent, affects all new workers as well.	2. Potentially high initial costs.
3. Potential productivity increases.	3. Lack of empirical data, especially productivity pluses.
4. Increased flexibility.	4. Only deals with one source at a time.
5. Reduced turnover.	5. Does not deal with individuals who have hypersusceptibility.
	6. Does not deal with personal sources of stress.

The principle advantage of job and environmental redesign is removal of the source of stress. Furthermore, the change can be permanent, affecting all workers who subsequently hold positions. In addition, claims of increased productivity are often made. Environmental changes may be costly, but have few other disadvantages. Organizational or job design changes represent a release of control by management, and are therefore, approached with much greater caution. Other advantages and disadvantages have been listed in Table 2-1.

Obstacles to Implementation of Control Strategies

There are few obstacles to implementation of strategies directed at changing the worker beyond the potentially high cost. Since a stress management program must be continuous and ongoing at all time in order to be effective, these costs can be substantial. Furthermore, the effectiveness of the program is predicated upon participation. Many such programs fail for this very reason. The most important question is, however, whether they are actually effective even with participation. There is very little scientific evidence indicating that they are.

The advantages of good working environments are fairly well documented (Harris, 1980; BOSTI, 1983). The obstacle is once again cost. Managers are seldom able to justify large investments in the work environment simply to increase job satisfaction or decrease job stress. Another incentive is required ano it is usually productivity. If the investment in capitol can be justified in terms of a pay back via increased productivity, the chances of making improvements in the workplace are tremendously increased. The BOSTI study estimated that the effect of good office design on job performance of managers and supervisors was $1600 per year per person; and almost $1700 for professional and technical workers (Westinghouse, 1983). The effect of good office design on job satisfaction amounted to over $400 per year for clerical workers. Other case studies are reviewed by Channer (1983).

While the virtues of humanization of work and QWL programs are frequently described in the press and discussed by academics, they are in fact seldom used. A New York Stock Exchange Study (1982) estimated that only 14% (7000) of the 49,000 corporations employing more than 100 people were involved in some type of human resource program (employee involvement) activity. Among corporations employing 500 or more employees: 46% of these programs included job design/redesign; 45% included surveys of employee attitudes; and 25% included labor management committees. Of the corporations employing more than 500 workers: 67% reported improvements in employee attitudes and morale; 55% increased productivity; 45% improved safety records; and 39% reduced absenteeism and turnover. In spite of reports such as the NYSE study and other reports describing the disadvantages of Tayloristic principles (e.g. U.S. HEW, 1973) and the advantages of worker participation and work humanization, it is obvious that the majority of employers remain unconvinced. Activity and interest will undoubtedly persist at some level, however. At least 22 states have funded QWL studies to evaluate the levels of activities within their states (Davenport, 19[illegible]3).

The obstacles described above are indicative of the existence of a more basic problem. That is, there are no adequate measures of the costs of job stress. While it has frequently been suggested that sick time, absenteeism, turnover, and reduced productivity reflect levels of job dissatisfaction and stress, these relationships have never been adequately quantified. While workers' compensation costs for stress related illness are on the rise, they do not yet constitute a significant financial burden. In brief, economic factors are not perceived as a significant incentive for reducing job stress.

Developing a Public Policy

The major difficulty involved in the development of strategies for reducing stress in the workplace relates to the difficulty of assessing risk. Control strategies are typically evaluated in terms of their ability to reduce risks to acceptable levels. For example, noise standards are established to assure that only a certain relatively small percentage of those exposed will experience a certain level of hearing loss. Likewise, an exposure level for a chemical can be established to assure that the risk of cancer will not be increased significantly. It is very clear that the establishment of standards for exposure to psychological stressors based upon the risk of developing ulcers, CHD or psychosis will not be satisfactory. Workers want to be free of the immediate tension, anxiety and frustration that they experience.

Some other approach is therefore necessary. The philosophy behind ACGIH TLVs (1983) offers a good model "The basis on which these values are established may differ from substance to substance; protection against impairment of health may be a guiding factor for some, whereas reasonable freedom from irritation, narcosis, or other forms of stress may form the basis for others."

Ergonomic Problems

Included in the first reports from Europe concerning potential adverse health effects associated with VDTs were accounts of frequent complaints about musculoskeletal and visual problems. These accounts also pointed out potential problems inherent in the design of commonly used displays, keyboards, work tables, chairs and lighting. Other studies soon demonstrated that there were often clear differences in these health problems which depended upon the types of task users performed. These reported health problems were therefore assumed to be caused by the poor fit between the worker and various aspects of the work environment. The discipline which has traditionally dealt with such concerns is called ergonomics. Ergonomics is the study of the relationships between the worker and the work environment. As generally understood, the basic philosophy of ergonomics is "designing work to better fit workers". Equipment and jobs which are not so designed can lead to psychological and physical stress that may affect health and well-being as well as performance.

While ergonomics as a field of study has a long history of research related to both industrial and office work, VDT-related health concerns have revived interest and popularized the subject, especially in the United States. Early U.S. studies of VDT-related complaints concluded that a variety of ergonomic problems existed. Three of these "ergonomic problems" will be considered in this section: musculoskeletal problems, visual problems, and fatigue. Poor design of equipment, jobs, or work environments may produce such problems.

In assessing the extent of such problems, two questions must be addressed. First of all, the frequency and seriousness of these problems among office workers must be considered. Secondly, the potential effects of office automation and specifically the use of VDTs must be considered.

Musculoskeletal Problems

Numerous reports of musculoskeletal problems among office workers are available. Problems range from complaints of discomfort to pain and medical disability. The most frequent sources of complaints are the back, neck and shoulders. Less frequent complaints concern the arms, wrists, hands and occasionally the legs.

Reported results from various studies are very difficult to compare since different measures of the seriousness and frequency of problems have been used. In addition, numerous studies have shown that the type of task being performed has an important bearing on the type of problems encountered. Table 2-2 indicates the percentage of workers typically reporting various problems on a "frequent" or "daily" basis, and is based upon the results of five studies.

The results of studies comparing VDT and non-VDT office workers have been inconsistent. It is generally agreed, however, that the type of task has a major influence on the results, which is often difficult to partial out. Two studies which attempted to do this by matching tasks (Starr, et al., 1982) and through multivariate analysis (Sauter, et al., 1982) came to the conclusion that the VDT itself did not contribute to muscular stress. While such studies seem to vindicate VDTs, it is readily apparent that the VDT plays a major role in determining the nature of the job and the adequacy of the workstation. In other words, the problem concerns the way the terminal is used. This has a significant bearing on the selection of appropriate control methods. A variety of studies relating to musculoskeletal problems have been reviewed by Arndt (1983).

Theories concerning the causes of problems are based upon biomechanical, physiological and anthropometric considerations. Poor working positions place greater loads on muscles, tendons and joints which increase the rate of fatigue. Constrained or static working positions lead to even more rapid fatigue. Chronic exposure to such stress may eventually result in physical disorders. Repetitive motions, especially of the hands and fingers may also lead to cumulative trauma disorders. Thus, the working posture as determined by the design of the workstation and the individual worker's body size; the

TABLE 2-2

Frequency of Reported Musculoskeletal Problems From Various Studies

	Percent Reporting Frequent or Daily Problems[1]		
	Neck-Shoulder	Back	Arm-Hand
Hunting et al., 1981 (n=295)			
VDT operators	6-12	6-10	6-12
Typists	6-12	6-10	6-10
Traditional office	2-5	2-5	2-5
Canadian Labour Congress, 1982 (n=2200)			
VDT	10-12	10-15	2-3
Non-VDT	7-8	9-14	4
Sauter et al., 1983 (n=333)			
VDT	24-34	27-35	3-4
Non-VDT	19-28	22-29	4-6
Hunting et al., 1980 (n=414)			
Data entry VDT	11-15	N.A.	6-15
Accounting machine	3-4	N.A.	8
Conversational VDT	4-5	N.A.	7-11
Typist	5	N.A.	4-5
Traditional office worker	1	N.A.	1
Arndt, 1980 (n=987)			
Telephone operators[2]	8-17	15	12
Service assistant[2]	9-14	14	6
Accounting clerks[2]	7-10	10	5

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[1] Results include percent reporting almost daily, frequent, often constant. Ranges represent multiple questions.

[2] Approximately 33% use VDT

N.A. = Not available

amount of time the position must be endured without adequate rest; and the frequency of certain motions, all may contribute to musculoskeletal problems in the form of fatigue and muscular pain; or inflammation of tendons, joints or muscles.

Based upon these considerations, a number of potential risk factors have been identified (Figure 2-1). The factors responsible for the occurrence of these risks have been identified as equipment design problems (including VDTs, workstations and chairs); and job design problems (including constrained working positions, repetitive work and inadequate rest breaks). As a result, recommendations, guidelines and in some cases standards have been proposed to alleviate some of these sources. Table 2-3 describes the type of design features which have typically been addressed.

Control Methods For Reducing the Incidence of Musculoskeletal Problems.

Ergonomic design. The most frequently recommended control measure is ergonomic design. The market has attempted to respond to this demand by providing "ergonomic terminals," "ergonomic workstations" and "ergonomic chairs". Although manufacturers have been slow to respond, nearly all companies now offer a VDT workstation and many offer adjustable workstations. Virtually all chair manufacturers are offering new "ergonomic" chairs. While only 6% of all office chairs are of this type, it is one of the fastest growing segments of the furniture industry and it has been estimated that by 1988 the number will reach 20% (NOPA, 1983). The cost of fixed budget grade VDT tables are in the range of $100-$300. The cost of an adjustable work table may be as low as $200 for those with a few features to more than $1300 for fully adjustable powered workstations. "Operator" or "task" chairs list for prices between $300-$700 (discounts are usually available). This is

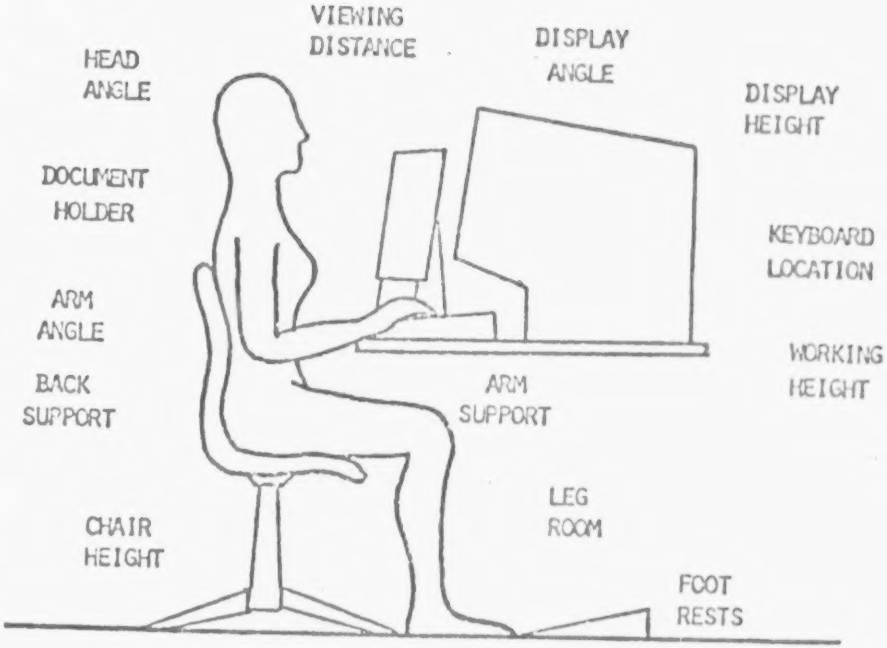

FIGURE 2-1. Potential ergonomic risk factors associated with office workstation design.

TABLE 2-3

Ergonomic Design Features Addressed by Standards and Guidelines

	Features
VDTs	Keyboard thickness
	Detachable keyboard
	Keyboard angle
	Keyboard layout
	Keyboard design
	Key tension
Workstation	Display height
	Keyboard height
	Display and keyboard distance
	Display and keyboard angles
	Adjustability
Chair	Backrest design, position and adjustment
	Height adjustment
	Seat pan design
	Ease of adjustment
Job Design	Total time on VDT
	Frequency of rest breaks
	Compensatory job activities
	Degree of variation in tasks

approximately 2-5 times the cost of the traditional budget grade secretarial or typist chair. Pneumatic adjustments add to the cost and make adjustments easier but are considered unreliable by many purchasers (NOPA, 1983). Ergonomic design features are now incorporated in many video display terminals and do not significantly affect the original purchase price of terminals.

A number of problems related to the implementation and effectiveness of this approach are evident:

1. the relationships between specific design features and musculoskeletal problems have not been empirically verified in all cases,
2. worker preferences may not coincide with ergonomic principles,
3. with the variety of features available, purchasers have difficulty determining which are necessary to solve their problems,
4. advertising hype about the ergonomic design of equipment is often inaccurate and useless, further complicating the picture,
5. little attention is given to non-VDT workers.

Job redesign. One of the most consistent results of research on musculoskeletal problems has been the recognition of the importance of the type of task being performed. Jobs which are highly repetitive and those involving constrained postures are associated with higher incidence rates of almost all musculoskeletal problems. Proposed solutions include enlarging jobs to increase the variety of activities performed and rotating workers to different jobs.

Two major obstacles are often present. First, in many industries there is not a sufficient variety of jobs or tasks available to allow the degree of freedom necessary in redesigning jobs. The second obstacle is the immediate additional training cost and the potential for increased labor costs inevitably associated with jobs requiring more skills.

There is also a tendency to believe that simplification of jobs increase productivity. Most of the advantages of job enlargement beyond the potential reduction of musculoskeletal problems are intangible and difficult to assess. These include such things as increased job satisfaction, reduced turnover, improved motivation, and greater perceived control.

Exercise. To the extent that constrained working postures contribute to musculoskeletal stress, regular exercise offers a potential source of relief. Other advantages are difficult to assess. Some reports are available that attest to the economic benefits of exercise components of health promotion programs in reduced illness and absenteeism (Fielding, 1979). In order to be effective, exercise would have to be interspersed throughout the day and would represent lost productive time.

Rest breaks. The effectiveness of frequent rest breaks has often been demonstrated in both industrial and office situations, according to Cakir, et al. (1980). In order to be effective, a rest break must be taken before significant fatigue occurs. Various recommendations concerning the frequency of rest breaks for VDT operators have been proposed (Table 2-4) by a number of parties. The scientific data available on the subject of rest breaks for office workers, comes from Japanese field studies. Using a variety of measures (work rates, errors, autonomic reactions, complaints, cervico-brachial disorders, and electromyography), these studies have led to a commonly recommended limit for continuous work of about 45-60 minutes, followed by breaks of 10-20 minutes. In Japan, many work places involving keyboard operations now comply with the 60 minute work and 10-15 minute rest cycles recommended by The Ministry of Labor notification (Kogi, 1982). It is generally agreed that intensive, repetitive work involving close visual work requires more frequent breaks.

TABLE 2-4

Break Schedules Recommended by Various Groups

Type of work	Minutes/hours	Source
Moderate visual demand	15/2	NIOSH recommendations,
High visual demand	10/1	Massachusetts Bill
Close work	15/1*	Australian Council of Trade Unions
Terminal work	15/2	Maine and Illinois bills
VDT work	15/1* 15/2	Newspaper Guild Model State Act
Terminal work	15/2*	Oregon Bill
Terminal work	20/2*	New York Bill
Moderate demands	15/2	National Association of Working Women
High demands	15/1	

*Rest or alternative work

Additional rest breaks represent lost productive time. Most employers find it difficult to overlook this fact and are unwilling to trade this loss for an unknown return in terms of reduced incidence of health problems or higher motivation and subsequent increases in overall effort and productivity. In some cases, this objection can be overcome by providing alternative work rather than additional rest breaks.

Medical evaluations. Periodic medical surveillance in the form of examinations or surveys of workers offer the possibility of detecting problems before they become disabling. Such information can also provide insight into the causes of such problems and may prove useful in the selection of preventive measures.

Summary. It is apparent that office workers experience a significant number of musculoskeletal problems. While most of these problems represent discomfort or pain, the potential for more serious problems certainly exists, especially when exposure is long term. The consequences cannot easily be measured in workers' compensation costs or lost time. For example, in the state of Wisconsin there were only five cumulative trauma injuries reported among secretaries and typists in 1982 (Wisconsin, 1983). It may also be difficult to establish the effect upon productivity. Thus, perceived economic consideration probably do not constitute a major incentive to eliminate such problems. It has been commonly observed that investments in any type of control will generally hinge upon some other motive. The most frequently asked questions in this regard concern potential increases in productivity. While there is evidence that increased rest breaks may resu in increased productivity, it is not familiar to, or sufficiently convincing to most employers. While other ergonomic solutions intuitively should improve performance, there is, unfortunately, very little evidence related to office settings to support this intuition. Two studies involving VDT tasks have reported productivity improvements in laboratory settings (Dainoff, et al., 1982; Springer, 1982).

Visual Problems

Vision problems (including eyestrain and burning/itching eyes) are frequently reported by all types of office workers and complaints occur more often in many VDT tasks. Other less frequent complaints include blurred vision, double vision, color fringes, and deterioration of acuity. Most of these complaints have surfaced as VDT-related problems, although they can usually be found in any type of work involving intensive visual demands. Table 2-5 presents a summary of typically reported rates of "frequently experienced" problems for VDT and non-VDT workers. Again, the issue of whether these experiences are somehow associated with the VDT itself has frequently been raised. A recent review of existing literature by a National Research Council panel (1983) led to the following conclusion:

> "We find no scientifically valid evidence that the use of VDTs per se causes harm, in the sense of anatomical or physiological damage, to the visual system. The symptoms of ocular discomfort and difficulty with vision reported by some workers who use VDTs appear to be similar to symptoms reported by people performing other near-visual tasks. Temporary changes in measures of visual function reported to occur following VDT work appear to be similar to those observed after performance of near-visual tasks in non-VDT jobs" (p 2-3).

It is a well-established fact that intensive use of the eyes leads to eyestrain and other subjective symptoms. There is also a long standing controversy concerning the relationship between close visual work and nearsightedness (Bear and Richler, 1982; Taylor, 1982). While a number of studies have noted transient functional visual changes (minutes to hours in duration) after performing VDT and other close work, there does not appear to be adequate evidence at this time to support the conclusion that permanent changes

TABLE 2-5

Frequency of Reported Visual Problems From Various Studies

	Percent Reporting Frequent Problems[1]		
	Eyestrain	Burning, itching, irritation	Blurring, double vision
Sauter et al., 1983 (n=333)			
VDT	24	19-27	5
Non-VDT	20	21-23	5
Laubli et al., 1980 (n=404)			
Data entry VDT	20	N.A.	N.A.
Conversational VDT	28	N.A.	N.A.
Typists	18	N.A.	N.A.
Traditional office	5	N.A.	N.A.
Canadian Labour Congress, 1982 (n=2269)			
VDT	N.A.	9-17	13-16
Non-VDT	N.A.	7-8	8-9
Sauter et al., 1982 (n=123)			
VDT newspaper editors	40	43-46	N.A.
Non-VDT newspaper editors	17	17-22	N.A.
Arndt, 1980 (n=987)			
Telephone operators[2]	8	N.A.	1-5
Service assistants[2]	9	N.A.	1-4
Accounting clerks[2]	6	N.A.	1-3

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[1] Frequency of problems reported daily, constantly, often, very often, frequently.

[2] Approximately 33% used VDTs.

N.A. = Not available.

occur (NRC, 1983). Many of the problems involved in evaluating vision complaints center around the difficulty of establishing the relationship between subjective complaints (e.g. eyestrain) and objective correlates.

A few studies (Starr, et al., 1982; Gould and Grischkowski, 1983) have demonstrated that under certain conditions, no differences can be observed between VDT and non-VDT work. This does not deny the fact that large numbers of office workers experience visual problems (regardless of the equipment used) nor that those working with VDTs tend to experience more frequent problems, as indicated in Table 2-5. Other studies have been reviewed by NRC (1983) and Helander, et al. (1982).

Visual Demands. The most consistent finding is that the intensity and duration of the visual demands of the job (regardless of whether a VDT is used or not) are correlated with the frequency of eye complaints. The difficulties encountered in attempting to quantify both visual demands and visual problems have so far prevented the formulation of clear and definitive guidelines for preventing or abating problems in actual work situations. Moreover, there are no clear studies which have established the efficacy of reducing visual demands through job redesign or more frequent breaks.

A number of theories have been advanced concerning potential risk factors. As mentioned above, close visual work has been one of these. Other established risk factors are the clarity and perceptibility of the image (including font, contrast, color, etc.) and illumination (including contrast, glare, reflection). Research has not yet established which factors are most important in office work. Correlations between symptoms and expected risk factors are typically small. This might suggest that a number of factors interact or that different factors produce the same results in different situations.

It has also been suggested that pre-existing visual deficiencies may surface more readily in visually demanding office tasks (Dickerson, 1976; Ostberg, 1977). While this has been established in some cases, it cannot totally explain the high frequency of problems witnessed (Smith, et al., 1982).

Eye Examinations. While there is currently no evidence that viewing VDTs leads to pathoanatomical changes, it is generally agreed that preplacement visual examinations for office workers employed in visually demanding tasks are an effective and worthwhile preventive measure. The evaluation of any types of eye problems being experienced by workers should also include an appropriate examination. The American Optometric Association (AOA, 1980) has reviewed eye examination requirements and recently recommended that VDT operators take steps to protect their own vision by seeking annual eye examinations (Chicago Tribune, 1983). The National Society for the Prevention of Blindness has also pointed out the essential requirements of preplacement visual testing including an emphasis on the job relatedness of the evaluation (Hirshfelder, 1980). These recommendations have been affirmed by NIOSH (Murray, et al., 1981). Other recommendations for eye examinations have been included in Cakir, et al. (1980, Appendix II); Desnoyers and LeBorgne (1982) and Whycer (1978). Most of the VDT safety and health bills introduced at the state level have included prescriptions for eye examinations.

The suggestion that eye fatigue among VDT operators can be lessened by the use of tints or color filters (American Academy of Ophthalmologists, 1982) is, however, highly questionable. As pointed out by Snyder (1982), tinted glasses may reduce VDT contrast, leading to greater difficulty in viewing while not effectively reducing potential sources of strain such as glare and screen reflections. Reading glasses, refracted for the actual viewing distance involved in a task, may be very helpful to individuals who wear glasses (especially bifocals).

Image Quality. The well-established relationships between the clarity and quality of the visual image and potential vision problems have led to a variety of suggestions for improvements in office work. Most of these have concentrated on VDT characteristics. These guidelines have included descriptions of optimal character size, font type, and minimum contrast. Other specifications which are aimed at less clearly established risk factors have concerned image color and negative contrast (dark characters on a light background). Since the image on the cathode ray tube must be repeatedly renewed, the characters may be subject to perceptible flicker or luminance variations and jitter or movement on the screen. While it is technologically feasible to alleviate or reduce all of these problems, different manufacturers have addressed them with varying degrees of vigor and success. In addition, many older models are still in use and are likely to remain in offices for some time. According to the National Research Council report (1983) "In many instances, however, VDTs have been designed without attention to existing scientific data on image quality, and many VDTs on the market do not provide the legibility of high-quality printed material" (p. 2). It has been estimated that nearly half of all VDTs now in use are improperly designed for intensive office use (Snyder, 1983). After 1500 hours of usage, a CRT is about half as bright as when new. The stroke thickness of characters is somewhat reduced and the apparent brightness of the display is diminished. Contrast and luminance controls can compensate for this aging, although some displays are not so equipped. Few suppliers make efforts to inform users of these maintenance and replacement requirements (Snyder, 1982). It appears highly probable that under certain conditions, the poor image quality of some VDT screens could contribute substantially to visual problems, especially when prolonged, intensive screen viewing is required.

Illumination. The third recognized risk factor is the illumination of the environment. Four basic problem areas have been identified: illumination level, reflections, glare and contrast.

Illumination level. Prior to energy conservation concerns, there was a tendency to believe that the more light there was, the better the environment would be for office work. As a result, many offices are currently overlit or too bright for certain activities. This is a particular problem in VDT offices. Increasing the light level, up to a point, improves contrast and visibility for most office tasks. However, VDTs emit their own light, and high illumination levels actually reduce the contrast and visibility of the screen image. Thus, while current recommendations for general office lighting are usually around 100 foot-candles (1000 lux), it is frequently suggested that the level be reduced to about 50 foot-candles or less for screen-based work (500 lux). An alternative recommendation is to provide even lower levels (30-40 foot-candles, 300-400 lux) while providing supplementary task lighting for other non-VDT work. Techniques for reducing illumination levels are readily available and a variety of suitable task lights have been marketed.

Reflections. Light reflected from objects within the field of view can cause discomfort and annoyance, and degrade performance. Shiny desk surfaces and keyboards are potential sources but some of the most serious problems are caused by reflections from the surface of VDT screens. A variety of control methods are available. One of the simplest is repositioning the VDT screen in relation to light sources. Room partitions, hoods or barriers may be placed between the screen and the source. Windows can be covered with venetian blinds, louver drapes, or shades. Special baffles, louvers, diffusers and refractors may be installed directly on luminaires. Many of these devices can be effectively retrofitted to existing systems at reasonable costs. Treatment of VDT screens may also be effective and is most appropriate where little control can be exercised over general environmental lighting conditions. This involves the use of a variety of surface coatings, treatments or filters to reduce reflections. While many VDT manufacturers now include some of these devices, the practice is by no means universal. One filter manufacturer reported that they supply 50,000 filters per month to VDT manufacturers (Sunflex, 1983). Filters can cost between $40 (micromesh) and $100 (circular polarized) each. One filter which is sold to an end user for $55, would cost the manufacturer $10 plus the cost of installation (Sunflex, 1983). The major disadvantages of manufacturer installation are potential reductions of image quality and the observation that the environment often determines the need for, and the most effective filter.

Glare. Discomfort and disability glare appear to be among the leading sources of discomfort. The sensation of glare is related to the intensity, size and location of the source as well as the background luminance or "light" level. Since the primary sources of glare in offices are windows and luminaires, jobs which require the individual to look forward rather than down are more likely to subject workers to such discomfort. Thus typists to some extent and even more so VDT operators are likely to encounter glare.

Glare control methods are very similar to those described for reflection control and include reducing the size, intensity and location of potential sources of glare within the environment.

Contrast. Another VDT specific problem relates to the positive contrast screens (light characters on a dark background) which are used in most terminals. Since VDT jobs often require alternating between white source documents and the darker screen, it has been suggested that the required continuous changes in the pupillary and retinal adaptation of the eye could lead to fatigue. There is, however, very little data available to evaluate the contribution of this factor to visual complaints. Research has not yet demonstrated any significant difference between negative and positive contrast screens. It should also be noted here that no particular screen or image colors appear to offer any particular advantages in terms of reducing eye complaints. It has been noted that the simultaneous use of colors from extremes of the visible spectrum (e.g. reds and blues) should be avoided since the eye cannot focus on both at the same time.

It appears unquestionable that illumination problems can play a significant role in contributing to visual complaints. While the application of conventional lighting design principles has generally lead to acceptable lighting in most traditional offices, the introduction of VDTs has necessitated the reconsideration of many accepted principles. Three unique characteristics of VDTs can be identified as important determinants of lighting design: the vertical orientation of the screen, the reflectance of the screen surface, and the light emitting nature of the display. Thus, it has become more difficult to design office lighting systems and office layouts and greater demands are being made on designer. While it is potentially feasible to design offices for VDT use, in most cases the problem involves adapting the existing environment to the new task. While the technology for accomplishing such control in a reasonably adequate fashion is readily available (and generally at acceptable costs), the problem seems to lie in the lack of widespread understanding of lighting principles and associated visual discomfort as well as in the proper application of available techniques. Many users depend upon vendors rather than lighting engineers for expertise and technical assistance. The appropriateness and cost effectiveness of various solutions depends upon an understanding of the nature of complaints. This will vary considerably depending upon the environment, the equipment and the job. As a result, no single control method can be expected to solve all problems and site-specific approaches are usually required.

Air Quality. The quality of air must not be overlooked as a contributor to certain types of eye irritation. The eyes are particularly sensitive to air contaminants including dusts, chemicals and allergens as well as low humidity. Very few studies of visual problems in offices have given consideration to air quality. The Canadian Labor Congress study (1982) results do indicate that those VDT operators who are bothered by dry air are more likely to report visual problems. The relationship was comparable in magnitude to the effects of poor lighting, and possibly stronger than the effects of other variables including hours on the VDT, frequency of breaks, time spent in screen viewing, flicker perception and a number of other variables. Extremely dry air may cause ocular irritation by interfering with lacrimation which may cause distress, especially for contact lens wearers. At humidities below 10-15%, corneal hypoxia may cause epithelial damage and edema.

Job Pressure and Stress. The functioning of the visual systems, and in particular the focusing apparatus of the eye, is affected by the level of stress experienced. While reported job pressures may be related to the visual demands of the job, the relationship between visual function and stress deserves further study.

Summary. Reducing the incidence of visual problems requires an understanding of all potential contributing factors including the visual demands of the job, the quality and clarity of viewed materials and the lighting conditions present. It is very likely that each of these factors plays some role in the development of visual problems and in many cases there may be interactions between factors. For example, an individual who experiences visual problems due to the demands of the task may then become more sensitive to adverse lighting conditions. Other factors including air quality and stress must not be overlooked.

Job Demands

Physical Demands. Excessive physical demands lead to fatigue. The physical demands of most office jobs are generally considered to be minimal at least in comparison to industrial jobs. The importance of constrained working positions must not be overlooked, however. Workers whose jobs require them to sit in one location for extended periods can be expected to experience muscular fatigue and pain. Maintaining a fixed posture places static loads on postural muscles. It is well-established that static loads must be limited to a maximum of 10% of muscle capacity if fatigue is to be avoided. In contrast to the dynamic muscular work associated with activity, the supply of oxygen is restricted and waste products are not removed. The result is rapid fatigue and muscular pain. Awkward or poor working positions tend to increase the load on muscles and greatly accelerate the fatigue process.

Thus, while good working posture with adequate support of the back, legs, head and arms will delay the onset of fatigue, movement is also necessary to alleviate the fatigue and pain associated with constrained positions. Any workstation design then will result in fatigue unless workers can actively compensate for static loading with changes of position and posture. The same phenomena has been suggested as a possible contributor to eyestrain among those who must focus on work at a fixed distance for extended periods of time.

Exercise has been one solution offered to prevent fatigue and would appear to be a reasonable one. Unfortunately, the time spent exercising is viewed as lost productive time and, therefore, is often not viewed favorably by employers. More frequent rest breaks during which the worker is allowed to move around offer similar advantages. The required frequency of rest breaks will depend upon the extent of postural constraint inherent in the job.

Variations in work tasks and working postures are often more acceptable techniques. It has frequently been pointed out that the introduction of office automation has led to simplification and increased repetitiveness in jobs resulting in greater postural constraints. While this hypothesis is difficult to document it is not an unreasonable one in view of the efforts of industrial engineers to increase productivity through the application of scientific management principles to office work. The promises and premises of these techniques may, in fact, often be counterproductive and must be carefully evaluated in light of their potentially adverse impact upon health and well-being.

Another potential solution which has been applied with some success involves designing workstations which allow variations in work position. While it is unlikely that minor variations in workstation position will successfully prevent fatigue, innovations such as stand up workstations may be helpful. It is a well-recognized fact in industrial ergonomics that workstations which allow alternating between sitting and standing are the most desirable.

Mental Demands. The demands of work which require continuous mental attention are particularly difficult to evaluate. Virtually all office jobs require mental activity whether it is simple and repetitive (data entry) or requires extensive decision making. Unlike physical workloads where the demands can be measured in terms of input parameters such as forces or weights and outputs such as cardiopulmonary responses or energy expenditure, there are no clear measurement techniques for evaluating mental workload. Furthermore, different dimensions contribute to the stressfulness of the mental work. At one extreme the job may require continuous attention with little decision making which leads to boredom. In prolonged continuous mental work, performance, especially of short-cycled repetitive tasks, becomes slower, more irregular and more prone to errors. Degradation of performance may occur within 30 minutes. Attention lapses and mental blocks become more frequent and are accompanied by feelings of frustration. Most of these performance changes can be attributed to losses of attentiveness, which can be deferred through introduction of rest breaks or alternate tasks. At the other extreme, the job may place excessive demands on critical evaluation or decision making abilities which also lead to stress and fatigue.

Performance, measured in terms of quality, errors, or quantity of work, is commonly used to evaluate mental activity. In many cases work performance is a very poor indicator of stress and fatigue since the worker is able to call upon reserve capacities to handle increased loads, and as a result no performance decrements may be observable. This is especially true in situations where workers are highly motivated due to inherent job interest, financial rewards, other social pressures or fears of jeopardizing their position. If reserves are continuously called upon, exhaustion eventually sets in, although it may not be evident until after the work shift. Under these circumstances, workers are less able to deal with other sources of irritation. It has been commonly observed that the tolerance for problems such as noise, poor chair design, glare, air quality, etc. are lower in mentally demanding jobs.

The only effective ways to directly control these problems are by reducing demands, utilizing more frequent breaks, and providing a variety of tasks (some requiring physical rather than mental activity). A frequent criticism of work simplification in automated offices is that it results in the removal of a variety of the more physically active and less mentally demanding tasks which usually accompany traditional office work (e.g. filing, copying, and telephone answering). The application of scientific management techniques to increase productivity frequently does not take into consideration the potentially adverse impact of removing these tasks from the job.

Summary

Increasing attention has been given in recent years to the way in which the job fits the worker. These ergonomic considerations have been stimulated by growing concerns over the potential adverse health effects of operating VDTs. These problems are in no way limited to VDT work. It does appear, however, that as a group, those who work at VDTs do encounter such problems more frequently than many other work groups. There are several possible explanations for this observation. First, there may be something inherent in the design or use of VDTs, although close examination of currently available data do not support such a conclusion. Secondly, those who use VDTs have not given adequate attention to the environment into which the equipment is introduced. In this sense, VDTs are unique since they do change the design requirements of both the workstation and the environment. Third, the introduction of VDTs has in many cases been accompanied by changes in jobs which have increased physical and mental demands on workers. The last two explanation are supported by research and observations.

Control strategies are available which can effectively reduce the ergonomic stresses associated with office work. These include improvements in the equipment, workstation, environment, and job design. In most cases, all will have to be used to some extent to effectively control problems.

Two major obstacles stand in the way of implementing these controls, however. The first involves the lack of definitive data which clearly establish the relationship between particular stressors and the resultant strain. It is, therefore, difficult to establish before hand the cost effectiveness of different control strategies. The second obstacle is the lack of understanding of problem sources and controls by those who purchase equipment and those who use it. This has been an obvious problem in offices where VDTs have been introduced. Conflicting claims and oversimplification of solutions coupled with limited understanding on the part of purchasers and users makes the application of existing knowledge and technology more problematic than might be expected. While many manufacturers of office furniture provide well-designed products, the claims of some that their equipment is designed using principles of ergonomics or human factors do not stand up to scientific scrutiny. In many cases, the selection of furniture and the design of the environment are highly specific to the task. While good design guidelines for specifying VDT display characteristics such as luminance, contrast, flicker, polarity, color, raster structure, jitter and temporal instability, font and character formation, it is difficult for manufacturers, purchasers and users to make comparisons between products because techniques for measuring and evaluating image quality have not been standardized and applied. The National Research Council (1983) recommended "that efforts be made to standardize measurement techniques" and that "Characteristic measures of products should be made routinely available to purchasers and user" (p. 3).

A variety of over-simplified approaches to dealing with ergonomic problems in the form of guidelines, standards and recommendations have been generated in the past few years. In practice, it is generally found that these approaches are of very limited use in solving the complex systems problems involved in the design of work and work environments. The wide variety of new products also offers consumers increased choices although access to these products still remains a problem. Correct choices also depend upon consumer understanding of ergonomic principles.

It has been suggested by some that adequate knowledge and information currently exists to solve the ergonomic problems encountered in modern offices. Such statements indicate a lack of understanding of the complexity of problems and the difficulties involved in abating problems. Future technological advances and applications may simplify these problems in some cases (e.g. flat panel displays) or complicate them further (e.g. voice communication, touch panels).

Temperature

One of the single most common sources of complaints from office workers concerns climatic conditions including temperature, humidity and air movement. While there is some individual variability in preferences for climatic conditions, survey data indicate varying levels of perceived discomfort are reported by many if not most persons in offices. A survey of 1004 office workers (Harris, 1980) reported that 55% considered the temperature in their workplace uncomfortable. There were no age differences although females more frequently reported uncomfortable temperatures. Forty-one percent of all workers indicated that their most recent complaint concerned room temperature and 37% of the entire sample indicated that they used portable heaters or fans. Fifty percent of 203 office executives interviewed indicated that temperature improvement for their employees was one of their most important needs. While these data were collected during the period in which regulatory standards for energy conservation were in effect, other studies not affected by this constraint have reported similar findings. Table 2-6 present the results of several studies on temperature.

The clinical symptoms caused by temperature influences include fatigue, headache, sweating, respiratory discomfort and changes in pulse frequency. While both temperature and air circulation can affect the distribution and build up of air contaminants and thereby affect health, there do not appear to be any serious health consequences related to the temperature variations normally encountered in office environments. Measures of general well-being, job satisfaction and psychological stress are most pertinent and informative in evaluating the health consequences of uncomfortable temperatures. While there are large individual differences in thermal comfort preferences, the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), a private standard setting group, has developed a voluntary consensus standard (ASHRAE 55-1981) which includes acceptable ranges for thermal comfort, meant to satisfy 80% of the average population. It specifies: (1) a range of 73°-79°F for the average clothed individual in the summer and a range of 68°-74.5°F in the winter, (2) relative humidity between 30-60% year round, and (3) an average indoor air velocity between .15 and .25 m/sec. Thermal comfort is affected by many things including the combination of air temperature and radiant temperature, air velocity, typical clothing, level of muscular activity, metabolism, and circadian and diurnal cycles. Thus, a constant temperature will at times be uncomfortable for the same individual.

TABLE 2-6

Frequency of Reported Temperature Related Problems

	Percent Reporting Problems		
	Heat	Cold	Dry Air
Canadian Labour Congress, 1982 (n=2330)			
VDT	19	23	45
Non-VDT	20	18	37
Harris, 1980 (n=658)			
Office workers			
Summer	37	13	
Winter	14	39	
Sauter et al., 1983 (n=333)			
VDT operators (summer)	25[1]	6[1]	
Non-VDT workers (summer)	24[1]	3[1]	

	Uncomfortable[2]
Arndt, 1980 (n=987)	
Telephone operators	72
Service assistants	71
Accounting clerks	65
Harris, 1980 (n=658)	
Clerical	61
Secretarial	55
Professional	49
Executive, managers, administrators	48

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[1] Includes only those reporting temperatures "much to high" or "much too low"

[2] (Arndt, 1980) Percent reporting uncomfortable or very uncomfortable temperatures
(Harris, 1980) Percent reporting temperature was not right

Despite this proliferation of variables, certain critical factors [illegible] be identified which will usually lead to unpleasant sensations. For example, local areas of temperature change such as vertical temperature gradients greater than 5°F, and radiative asymmetries exceeding 9°F in a vertical direction or 18°F in a horizontal direction will be experienced as uncomfortable. Thus, sitting within 4-5 feet of a glass wall on a hot or cold day may be uncomfortable regardless of the room temperature. Sitting near heat producing equipment such as VDTs, copiers and lighting may also lead to discomfort.

Most offices use a central mechanical ventilation system which creates an integrated building system. Consequently, the climates of individual rooms become interdependent. Changes in activities, or additional personnel or equipment in one room will result in an imbalance in that location or elsewhere which may not be easily corrected.

Ventilation during heating and cooling seasons is usually provided by the same system, which can create problems since the air movement and mixing of heated air is different than that of cooled air. Furthermore, in a cool or neutral environment, air movement may be felt as uncomfortable, while increased air movement in a warm environment is desirable and extends the comfort zone to higher ambient temperatures.

Some of the control measures available are well-established and readily available. One of the most straight forward is an adequate and accurate assessment of the factors which affect discomfort. As indicated above, these factors may result in unequal temperatures throughout a building or even within a single open office area due to the placement of windows and heat producing equipment. The addition of portable room partitions, interior surfacings or fixtures can also effect the ventilation of certain work areas.

This problem could be alleviated somewhat by the expected introduction of systems furniture with integrate ventilation ducts.

Too often, individual complaints are considered to be indications of personal differences and, therefore, are thought to be beyond the control of office managers or building maintenance engineers. It is, however, well-established that temperature perception is directly related to the actual effective temperature, suggesting that greater attention to temperature and ventilation variations could significantly reduce discomfort. When individual preferences do vary, careful assessment and judicious selection of work areas to accommodate individuals can often solve problems.

While detailed design standards for heating and ventilation exist, they admittedly are not based entirely upon hard scientific data but often on the judgment of "experts". In addition, design standards indicate how a system is supposed to operate, and the actual performance of the system can vary considerably due to design errors, changes in occupancy or activity, addition of equipment or partitions, and improper or inadequate maintenance. Continuous attention must be given to these problems by management.

One of the obstacles to providing a comfortable climate is the difficulty associated with making accurate and detailed measurements, which building engineers are neither equipped or trained to perform.

The primary advantage of providing a comfortable climate (beyond improved comfort and well-being) relates to improved productivity. It is clear that productivity can be adversely affected by uncomfortable temperatures (Fanger, 1979). Both employees and executives appear to be convinced of this fact (Harris, 1980). The principle causes of commonly encountered problems would, therefore, appear to be the lack of attention, inadequate information and limited resources for making corrections.

Humidity

Humidity problems in offices can contribute to a number of adverse health outcomes. While very little data concerning actual humidity levels exist, it can generally be observed that very few office HVAC systems include any method of controlling the level.

It is generally believed that dry air leads to chronic irritation of the nasal and bronchial passages. Often noted is desiccation of the mucous membranes of the air ducts which could obstruct the flow of mucous over the ciliary tracts, resulting in a diminished resistance to infection. These medical interpretations have been confirmed by several studies. The potential significance of the problem must be considered in light of the fact that respiratory problems are the leading cause of restricted activity in the U.S., averaging about six days per person per year. A number of studies have demonstrated that increasing humidity is associated with decreasing absenteeism (Green, 1982). It has generally been concluded that humidities of 40-50% are desirable, and below 30% they become unhygienic. It has also been reported in a number of cases that outbreaks of skin rashes were related to humidities below 30-40° (White and Rycroft, 1982; Rycroft and Smith, 1980). Raising the humidity above 45% effectively eliminated these problems.

Extremely dry air may also cause ocular irritation by interfering with lacrimation which can cause distress, especially for contact lens wearers. Corneal hypoxia with very low humidities (e.g. 10%) can cause epithelial damage and edema. Dry air must be considered as a more serious risk factor in jobs which have high visual demands, since it may exacerbate the frequently reported complaints of eye problems in such tasks. For example, the Canadian VDT study (CLC, 1982) reported a strong direct relationship between complaints about dry air and eye irritation. In fact, the relationship was as strong as any other variable, including illumination.

Low humidity may be a special problem around certain electronic equipment due to heating effect which act to reduce the relative humidity close to the equipment. Low humidity and static build-ups near VDTs have been implicated as causes of facial rashes in a small number of medically documented cases (Linden and Rolfsen, 1981).

Studies at the ASHRAE Research Laboratory have indicated that odor perception and irritation due, in particular to cigarette smoke, are lowered with higher relative humidities (Kuehner, 1956). While the perceptible odor level of cigarette smoke decreases with exposure time, irritation to the nose and eyes generally increases. The irritation is greatest at low relative humidities. ASHRAE (1981) recommends a minimum of 45% relative humidity to control odor perception and irritation.

High humidities (above 50%) do not appreciably improve health conditions and may lead to other problems including equipment damage, condensation, and growth of micro-organisms.

Relative humidity does not appreciably affect thermal comfort if the temperature is maintained within a reasonable comfort range (73 to 78°F). As the dry-bulb temperature increase above 78°F, humidity effects becomes very important as evaporation becomes the major source of heat loss. An increment from 30% to 70% provides about the same change in thermal sensation as a one degree centigrade increase in temperature. It is, therefore, much more economical to control air temperature to attain thermal comfort.

ASHRAE 55-1981 recommends a relative humidity between 30% and 60%. A variety of humidification systems exist, although the selection and application of equipment involves consideration of both the environmental conditions of the occupancy and the characteristics of the building. Humidification may be costly and difficult with certain types of non-central HVAC systems, and should be a factor in selection of systems in new buildings.

Air Quality

Concerns about indoor air quality have been a topic of increasing concern in recent years. Some of the attention can be traced to heightened public awareness of the importance of air quality and more recently to the appearance of the general topic of indoor pollution of homes, public buildings and offices. Energy conservation measures (reduced ventilation and "sealing" of buildings) initiated in recent years, have in some cases contributed to the seriousness of these problems. Energy conservation efforts have often been blamed for the increasing number of complaints about "sick building syndrome" or "stuffy office syndrome." Although there is some truth to these claims, the actual situation is considerably more complex. For example, where outdoor air quality is low, energy conservation measures may improve indoor breathing air quality.

Other factors which may have contributed to increasing office air quality concerns have risen out of general public awareness. Some publicity has been given to reports of the adverse health effects associated with passive cigarette "smoking," asbestos in buildings, formaldehyde gases from urea formaldehyde foam insulation, radon decay products, and public health indoor air disasters such as the outbreaks of Legionnaires disease in 1976, and the state office building fire in Binghampton, N.Y., in 1981 in which toxic soot containing polychlorinated biphenals contaminated the building.

In general terms, there is a large potential for generation of office air pollution from occupational activities, use of equipment, chemicals, the wear and tear and outgassing of some structural or decorative materials, the influence of thermal factors and intrusion of outdoor pollutants.

In order to systematically evaluate risks, one must examine the number of individuals exposed, the severity of exposure and the consequences of exposure. Unfortunately, there is a noticeable lack of information available on all of these questions. Accurate assessments of risk are, therefore, very difficult to develop and estimates must be made on the basis of anecdotal, incidental or otherwise limited reports of exposures or health problems. In many cases, objective verification of the direct causes of symptoms is difficult, even when severe. It has been suggested that in some cases in the occupational health literature, an inability to detect or determine direct causal links has sparked the conclusion that observed symptoms are psychogenic in nature ("psychogenic contagion reactions," or "mass hysterical reactions") (Faust and Brilliant, 1981).

Number of Office Workers at Risk

There are remarkably few accurate assessments available concerning the number of people at risk, both with respect to health outcome and symptom report data in investigations of offices. The National Institute for Occupational Safety and Health has conducted more than 180 indoor air quality investigations since 1978, most in response to worker complaints of eye, nose, and throat irritations; headaches; skin rashes and fatigue. (Occupational Hazards, 1983). The New York City Department of Environmental Protection reported receiving 98 complaints in a 7 month span related to both residential and workplace sources of indoor pollution (Ferrand and Moriates, 1981). Such data only suggest there are problems but do not allow any estimates of the total number of persons exposed.

The data concerning health symptoms or potential hazards related to office work (even self-reported survey data) are also scarce and are difficult to assess in any case. Symptoms are not always associated with workplace exposures, sometimes lack consistency between individuals, and human sensory systems do not always provide sufficient detection capability to gain infallible signals about the safety of the environment. One example of available survey results comes from the report of an office workers advocacy group (Gregory, 1981). Of those office workers completing the survey, 40% indicated they "had no fresh air" and 25.4% reported exposure to irritating fumes. Unfortunately, the survey response rate was exceedingly low (less than 9%) which unfortunately introduces strong possibilities that persons answering were not "typical". An industry sponsored study of office workers (Harris, 1980) (which does not report response rates), found that 30% of the office workers interviewed thought their office was "too stuffy". While most individuals worked where unrestricted cigarette smoking was allowed (94%), only about 1/3 were regular smokers. Of the nonsmokers, 26% said they were bothered a great deal, 17% somewhat, 11% hardly at all, and 43% not at all by the smoke. It is not possible to ascertain from the data whether ventilation was adequate, work locations were widely separated, or workers simply weren't "bothered".

In another study of over 2300 office workers (response rate 81%) from 15 different offices, it was found that 57% reported "poor" or "very poor" air circulation in their offices (Canadian Labour Congress, 1982). Table 2-7 indicates the frequency of reported problems from three studies.

TABLE 2-7

Frequency of Reported Ventilation Problems

	Percent reporting inadequate air circulation
Harris, 1980 (n=658)	
Clerical	40
Secretarial	22
Professional	29
Executives, managers, administrators	35
Canadian Labour Congress, 1982 (n=2330)	
VDT	35[1]
Non-VDT	29[1]
Professional/administrative	17[1]
Arndt, 1980 (n=987)	
Telephone operators	54[2]
Service assistants	37[2]
Accounting clerks	43[2]

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[1] Percentages reported indicate only those indicating ventilation was "very poor"
An additional 24% of all those surveyed indicated ventilation was "poor".

[2] Percent reported very uncomfortable or uncomfortable.

Severity of Exposures

While data on exposure levels in offices are again limited, The National Research Council's report on Indoor Pollutants (1981, pp. 11-12) concluded "... there is direct and circumstantial evidence that human exposures are large enough and common enough to account for substantial morbidity and premature mortality." These exposures can be substantial in unusual circumstances and can, in some cases, exceed ambient outdoor air quality standards. Generally, however, reported concentrations of indoor air contaminants are quite low. For example, of 15 office health hazard evaluations reported by NIOSH between 1980 and 1981, only 3 cases involved unacceptably high concentrations. In each case the exposures were related to specific sources in specific locations (NIOSH HHE reports, 1980-81, 1982). A survey of 30 offices by the Bureau of Chemical Hazards of the Ontario government found that the levels of all identified compounds (volatile organics) were well below their respective ACGIH, 8-hour TWA-TLV values (Otson, et al., 1983). Other studies have reported similar findings. After collecting air samples within four offices in which occupants had complained of dizziness, drowsiness, inability to concentrate, stuffiness, and general poor air quality, Miksch, et al. (1982) concluded that ... "relative to outdoor air, the concentrations of a variety of organic solvent vapors generated within and contained by the built environment are high. When compared with concentrations recommended for protecting the health of workers in industrial environments, the concentrations of individual organic chemist contaminants are lower by 2-4 orders of magnitude. The additive exposures, expressed as the sum of the percentage ratios of individual organic chemical contaminants to their recommended exposure levels, does not exceed more than a few percent" (p. 136). Since most Americans spend 80-90% of their time indoors, even low level exposures may make substantial contributions to time weighted exposures, however. Many of the air pollutants found in office environments are also found in the home.

Health Consequences

At high concentrations, indoor air contaminants may cause irritation of sensitive tissues, illnesses, and death from acute as well as chronic exposures. Epidemiological data concerning the incidence or prevalence of adverse health effects is lacking and many of the conclusions about potential effects must be drawn from studies performed in other environments or carried out under controlled conditions. For example, the adverse health effects of exposure (even at low levels) to such contaminants as asbestos, formaldehyde and tobacco smoke are well-documented. Often overlooked and less well-researched are the effects of airborne viruses and bacteria. Other substances can also lead to adverse effects on health but apparently only after prolonged or repeated exposure. These contaminants include substances that accumulate in the body, substances that cause relatively little harm to tissue with a single exposure but produce cumulative effects if exposure is repeated, and infectious agents which are more likely to cause health problems if exposure is repeated. Other airborne materials may cause sensitization phenomena in selected individuals which can later result in reactions of greater severity occurring at very low exposure levels.

Many substances appear to act primarily as irritants at low exposure levels by inducing local inflammatory reactior n the eyes, nose, lung or other sites, but the long term and synergistic effects of chronic exposure are largely unknown. While the discomfort associated with low level exposures to dusts, gas, vapors, allergens or odors obviously affect general well-being, cumulative exposures to polluted air may also act as a source of stress.

It is impossible to determine with any certitude the economic burden associated with increased health care, lost work time, lost production and turnover which may be associated with polluted air.

Sources of Air Pollution in Offices

It is beyond the scope of this report to identify all of the potential sources, effects and exposures to air contaminants in office environments. The general categories of contaminants are listed in Table 2-8.

Control Strategies

There are five basic control strategies that can be used to reduce exposure to indoor air contaminants: (1) ventilation, (2) source removal, (3) source modification, (4) air cleaning, and (5) education and behavior change.

Ventilation. Concentrations of contaminants are often reduced by local exhaust at the source or by dilution of the contaminant with fresh or clean air.

Source Removal. Sources of hazardous substances may be removed or less hazardous materials may be substituted.

Source Modification. Emission rates may be reduced through engineering modification of equipment processes, changes in equipment use practices, or contaminants may be contained by a barrier or sealant.

Air Cleaning. Air contaminants can be removed from air by a number of different devices or processes, often within ventilation systems, before air is recirculated.

Education. Information concerning the contents and hazards associated with various products and materials, the characteristics of equipment operation or product uses which contribute to emissions, and training concerning

TABLE 2-8

Examples of Types of Air Containment Exposures in Offices

Contaminant	Standard	Exposure Levels	Examples and Sources
Micro-organisms, allergens	None	Potentially high	Bacteria, viruses, fungi; contamination of humidifiers and air conditioners can cause disease, fever, infectious lung diseases, hypersensitivity pneumonitis. Allergens cause sensitization in some individuals.
Organic chemicals	Exist for some chemicals	Typically low, below TLV for individual chemicals .	Sources include building materials, consumer products, tobacco smoke, building maintenance products, wet process photocopiers, and bioeffluents. Formaldehyde is one of the most serious.
Gases	Some standards exist	Typically below existing standards	Cigarette smoke, outside sources, combustion processes, and equipment are potential sources of gases, including carbon monoxide and ozone.
Asbestos	OSHA standard	May exceed standards when disturbed	Disturbances of insulation and building materials due to removal, renovation, maintenance work and care may produce high levels. Natural deterioration of surface may lead to contamination of air supplies.
Tobacco smoke	None	Potentially high levels	Passive smoking has been implicated as a contributing factors in certain instances of cancer, cardiovascular effects, and respiratory effects. Asthma and allergic rhinitis patients are especially vulnerable to irritant effects.
Other sources	None applicable	Typically short exposure, potentially high brief exposures	Numerous other office products such as glues, cleaning solvents, deordorizers, correction fluids, and coloring pens are potential sources of episodic exposure to air contaminants as well as skin contact.

safe handling can be provided to workers. This allows individuals to take steps to avoid or limit exposures.

Application of Control Strategies

While adequate control of indoor air pollution is technically feasible, since well-established methods are clearly available, the major problem appears to lie in selection and design of the appropriate strategy for specific situations and substance combinations. Source removal, source modification, isolation, and air cleaning can be effective controls, but all require that the source be identified. Identification and quantification of air contaminants which appear to be causing complaints are often very difficult due to the low exposure levels usually involved and the lack of adequate information concerning what exposure limits must be achieved, especially when several substances are involved.

Education of employees, especially concerning the use of office products and associated hazards, depends largely upon accurate and complete product information, labels, and warnings which are often unavailable. Market forces can provide a potentially powerful influence on the availability of such information although this has generally not occurred, and governmental intervention can result in more valuable and widely available information. Thirteen states and 35 cities and counties have adopted "right to know" or "hazard communication" legislation (New York Times, 1983). OSHA has promulgated a standard but it is not as strict as most state laws and affects only employers in the manufacturing sector. It is unclear whether the federal standard will preempt state and local laws.

The primary method of controlling air contaminants in most buildings is general ventilation. The quality of air provided by ventilation depends directly upon the amount and quality of fresh outside air added (or quality and proportion of recirculated filtered air) and the air mixing capabilities of the system. Fresh outside air is added through the ventilation system, by natural ventilation into the building (e.g. doors or windows), and by infiltration through building structures or surfaces.

Energy conservation efforts have concentrated on reducing the amount of outside air drawn into interiors to a minimum since such air must be conditioned before entering the system. Thus, sealing of buildings and reductions in ventilation can have significant effects on air quality. Air mixing is affected by a number of building air system factors such as the ventilation rate, thermal factors, air diffuser design and placement, air velocity, obstructions and occupant activities.

Most ventilation systems are designed to meet specific design standards established by state or local building codes. The American Society of Heating, Refrigeration, Air Conditioning Engineers (ASHRAE), a private standard setting professional organization has developed specifications which are often incorporated or referenced in these codes (ASHRAE 62-73 or the revised ASHRAE 62-1981). Unfortunately, ventilation specifications and design do not guarantee adequate dilution or removal of contaminants during actual system operation in specific buildings or particular building areas. ASHRAE 62-1981 only specifies minimum air exchange rates and provides numerical limits for maximum indoor air concentrations of a variety of pollutants including tobacco smoke. The recommended design concentrations in 62-1981 Appendix C are one-tenth of the TLV guidelines. In practice, the specifications are used during the ventilation planning stages for new or remodeled buildings. Since there are no performance standards, there can be no guarantee that the system operates as it was designed or that individual exposures will be adequately controlled. Local modifications including closing of vents, changes in types and settings of diffusers, sealing of buildings, placement of wall partitions; as well as inefficient filtering, reductions in make-up air and thermal factors all effect the performance of the ventilation system. There is virtually no field enforcement of standards related to ventilation system performance in operational systems. Furthermore, quantitative air systems performance evaluation is expensive and elaborate. Routine gathering of detailed ventilation and contaminant measurements is beyond the capability of most building staffs. The resources and information available to building maintenance and engineering personnel do not presently allow changes in this state of affairs. The scope of the problem is indicated by observations made in federal facilities by building inspectors who noted that "outside air in many buildings is reduced to zero" in spite of the fact that federal regulations suggest a 10% recirculation rate (Repace, 1981).

Research Needs

It is readily apparent that more research is necessary to determine sources and distributions of air contaminants, exposure levels and associated health effects (especially at low levels), potential synergistic effects, and populations at risk. Methods for examining the quality of air reaching each office occupant rather than total ventilation rates must be established. Mixing and dispersion of contaminants from sources in rooms have not been extensively investigated. Research is also necessary to establish the most effective and economical control strategies. ASHRAE believes that once this research has been carried out the market can then respond with improved, innovative and cost-effective solutions (ASHRAE, 1982). There is little evidence, however, that public perceptions of the direct, indirect and social health costs associated with indoor pollutants are of sufficient depth or breadth to alone affect markets substantially in the near term, or probably, the foreseeable future.

Information presented at recent subcommittee hearings (August, 1983) of the House Committee on Science and Technology indicated that federally supported research on indoor air quality has been minimal in recent years. At least four agencies (Environmental Protection Agency, Department of Energy, Health and Human Services, and Consumer Product Safety Commission) may share some responsibility for such research. EPA indicated they had no regulatory authority and had no need to perform indoor air research, and requested no funding for FY84. DOE likewise requested no funding. Both were appropriated funds by Congress, however (Hileman, 1983).

Economic Considerations

In addition to the obvious potential health effects, other factors including discomfort, decreased productivity, lost work time, the soiling and corrosion associated with contaminants and increases in maintenance and housekeeping must be considered in evaluating the benefits of reduced air contamination. The primary cost factor is energy. Heat exchangers which conserve energy without reducing ventilation rates, substitution or removal of contaminant sources, emission reduction techniques, and air cleaning devices are relatively inexpensive methods of controlling air contamination which have not been adequately utilized and which do not effect energy costs as much as increasing ventilation. Other techniques such as periodic purging rather than continuous mixing with outside air may prove economically beneficial (Meyer, 1983). Adaptation of passive air sampling techniques to clean air is also attractive from the standpoint of operating energy economy (Billings and

Vanderslice, 1982). In many cases, merely training maintenance personnel in basic techniques of optimizing existing system operational capabilities from air quality, energy and human factors standpoints simultaneously, can yield substantial gains with little further resource expenditure and often with cost savings.

Ultimately however, it would be most desirable and efficient to be able to determine ventilation and control requirements based upon adequate knowledge of contaminant levels and their associated health effects.

Noise

Noise in offices seldom reaches levels which would impair the hearing of a substantial number of people although in certain situations levels in access of 80 dBA can be reached which will affect the hearing of some individuals. Noise of this intensity could, for example, be associated with office equipment placed very close to workers. High speed printers are one such source of noise. Working in small enclosed areas with a number of pieces of equipment will exacerbate the problem.

More common, however, are noises which are irritating, affect performance, or generally cause stress. Table 2-9 summarizes the results of several studies which have asked individuals about noise in offices. The most frequent source of irritating noise is conversation. Most susceptible are those performing work requiring concentration. Telephone conversation also becomes difficult. Traditional "bull pen" and open plan offices are particularly likely to lead to this type of problem, the latter due to the fact that partitions or panels often do not go up to the ceiling and sometimes not to the floor. Some workstations are enclosed on only two sides. Telephones, office

TABLE 2-9

Self-Reported Noise Problems in Offices

Study	Percent reporting noise problems	
	Much too high	Somewhat high
Sauter et al., 1983 (n=333)		
VDT operators	14	44
Non-VDT workers	20	54
	Too noisy	
Canadian Labour Congress, 1982 (n=2330)		
VDT	54 (varies by job, 11%-72%)	
Non-VDT	39 (varies by job, 26%-48%)	
	Do not have quiet	
Harris, 1980 (n=658)		
Clerical	53	
Secretarial	42	
Professional	49	
Executive, manager, supervisor	30	
(n=853)		
Conventional office	37	
Bull pen office	71	
Open office	50	
	Uncomfortable	Very uncomfortable
Arndt, 1980 (n=987)		
Telephone operators	49	20
Service assistants	51	13
Accounting clerks	49	18

machines and activities of other workers are sources of distraction for the same reasons.

Other sources of irritating noise include office equipment and ventilation systems. Some electronic devices emit high frequency (low level) sounds which can be particularly irritating.

In many cases, irritating and distracting noises are described as a source of stress. The commonly experienced displeasure with sounds such as a dripping faucet or chalk scraping on a blackboard serve as clear examples. Conversational noise can act as a stressor by interfering with attention or performance.

Noise is known to cause certain nonauditory effects such as vasoconstriction of small blood vessels, changes in blood pressure, decreased respiration rate and increased muscle tension. These may simply be manifestations of a generalized stress response. The long term effects of such response are unclear. Reported affects have usually been associated with fairly severe exposures.

The speech interference, distraction and irritation caused by noise are dependent upon the loudness, the frequency, and the temporal characteristics of the noise. Ordinarily, higher frequencies cause more problems, both in terms of irritation and speech interference. Conversation becomes difficult at levels above 55-65 dBA (depending upon distance between speaker and listener). Telephone conversations may require lower levels unless amplifiers are used in ear pieces.

Noise control technology is well-developed and readily applicable to office environments. As with most control methods, retrofitting is usually more expensive and difficult than prevention in design stages. Noise control strategies used in offices involve either eliminating or controlling the source or interrupting the transmission path.

The best way to control equipment noise is to buy quieter equipment. The materials from which equipment is constructed as well as the amount of sound control engineering built in can significantly affect noise generation. Rubber pads or isolation damping devices can be installed under noisy equipment including typewriters to reduce vibrations and transmission to furniture and floors. Fan noise can sometimes be controlled by substituting fans of different design. Sound enclosures can be purchased or constructed for some equipment such as printers. Equipment noise can also be controlled by placement farther away from workers and even in separate rooms if possible.

Noise from ventilation systems can sometimes be reduced by installing baffles or diffusers of different designs, although care must be exercised to avoid degrading ventilation system performance.

Controlling noise in existing open plan offices can be highly problematic. In the design stage, attention to the height, sound transmission characteristics, and arrangement of work areas can result in better noise control. Door panels will soon be available as well. Another method which can be used is zoning the office into different areas depending upon equipment use, telephone use and conversation frequency, which reduces the exposure of at least some of the workers. Acoustical treatment of floors, walls, ceilings and windows can help but is fairly expensive and is usually not as effective unless the primary noise path is due to reflections from these surfaces.

In some cases, masking noise has been introduced to decrease the distracting effects of outside conversations and also provide privacy in conversation. Masking noise does, however, add to the overall noise level and could itself be a source of irritation.

Accidents and Injuries

As in any work environment, accidents can cause personal injuries in offices. Some of these injuries can be serious and appropriate safety measures must obviously be taken. Some of the most serious incidents have involved fires in high rise offices where inappropriate attention to exits and training drills, or inadequate alarm systems and fire control measures have contributed to unnecessary injuries and fatalities. The incidence of injuries among office workers is, however, very low in comparison to blue collar occupations.

Data related to injuries among office workers are difficult to obtain since most statistical analyses are categorized by industry type rather than occupation. In order to make some assessment of the nature and type of injuries suffered by office workers, the results of the 1982 Supplementary Data System for Occupational Injuries and Illnesses in Wisconsin were examined (Wisconsin, 1983). The data were compiled by the State of Wisconsin under contract with the Bureau of Labor Statistics. The results, tabulated by type of accident (Table 2-10), and nature of injury (Table 2-11), for the major white collar occupational classifications and selected clerical occupations are included.

Accident Types

Over-exertions and falls were the two most frequent types of accidents among white collar workers, accounting for just over half of all injuries. Among the selected office occupations, the distribution was somewhat different. Falls accounted for 46% of all injuries among this group. When these results are compared with those for all occupations combined, the most noticeable difference is the higher percentage of accidents attributable to falls among white collar workers (23% vs. 14%).

TABLE 2-10

Accidents Among White Collar Workers in Wisconsin by Type of Accident-1982

Occupational Classification				Type of Accident				
	Total Injuries	Over Exert.	Falls	Struck By	Bodily Reaction	Caught In	Motor Vehicle	Other
Prof/Tech	1351	390 (29)	264 (20)	256 (19)	160 (12)	23 (2)	49 (4)	209 (15)
Adm/Man	1183	377 (32)	271 (23)	200 (17)	96 (8)	46 (4)	54 (5)	139 (12)
Clerical	1636	509 (31)	423 (26)	279 (17)	137 (8)	61 (4)	30 (2)	197 (12)
Sales	699	194 (28)	172 (25)	107 (15)	56 (8)	13 (2)	63 (9)	94 (13)
All White Collar	4869	1470 (30)	1130 (23)	842 (17)	449 (9)	143 (3)	196 (4)	639 (13)
All Occupations	50860	15238 (30)	7072 (14)	10426 (20)	3272 (6)	2761 (5)	1115 (2)	10976 (22)
Selected Occupations								
Secretaries	82	16	52	13	6	1	2	1
Typists	38	8	16	5	2	3	1	3
Receptionists	14	3	6	1	2	--	1	3
Telephone Oper.	12	1	7	1	--	--	--	3
Bookkeepers	28	2	8	6	5	1	3	3
TOTAL (Percentage)	174	30 (18)	80 (46)	23 (13)	18 (10)	5 (3)	7 (4)	11 (6)

TABLE 2-11

Accidents Among White Collar Workers in Wisconsin by Nature of Injury-1982

Occupational Classification	Nature of Injury						
	Total Injuries	Sprain Strain	Cuts Lacer.	Contusion Bruises	Fracture	Illness	Other
Prof/Tech	1351	594 (44)	82 (6)	74 (5)	156 (11)	124 (9)	321 (24)
Adm/Man	1183	428 (36)	86 (7)	67 (6)	173 (15)	54 (5)	375 (32)
Clerical	1636	718 (44)	111 (7)	174 (11)	165 (10)	114 (7)	354 (22)
Sales	699	290 (41)	42 (6)	52 (7)	84 (12)	30 (4)	201 (29)
All White Collar	4869	2030 (42)	321 (7)	367 (8)	578 (12)	322 (7)	1251 (26)
All Occupations	50860	20676 (41)	5215 (10)	4745 (9)	4243 (8)	3216 (6)	10476 (21)
Selected Occupations							
Secretaries	82	30	8	15	9	2	18
Typists	38	10	5	7	4	3	9
Receptionists	14	5	1	--	2	--	2
Telephone Oper.	12	4	--	3	2	1	2
Bookkeepers	28	4	--	6	5	5	8
Total (Percentage)	174	53 (30)	14 (8)	31 (18)	22 (13)	11 (6)	39 (22)

Nature of Injuries

Sprains and strains were the most frequent injuries (42%) among all white collar workers. Among the selected office occupations, the incidence of sprains and strains was somewhat lower (30%) and the incidence of contusions and bruises was higher. Illnesses accounted for 4-9% of the reported injuries, depending upon occupational classification. The nature of injuries suffered by white collar workers were generally representative of the entire working population.

Estimation of Injury Rates

The Wisconsin SDS data were also used to estimate injury rates in office occupations. The Wisconsin data include only cases involving fatalities, permanent disabilities, four or more calendar days of disability, and a few cases which do not meet these requirements. The data therefore underestimate the total number of injuries by some unknown amount; and the number of lost work day cases, possibly by a factor of 1.5-2. The SDS injury data were used in conjunction with 1980 census data. Since census data were used, [illegible] calculated frequency rates would not be comparable to typical injury rates based upon 100 man-years. The data can, however, be used to estimate the total number of injuries expected in the U.S. The distribution of employment by occupation within Wisconsin was compared with the U.S. distribution, in order to determine multiplying factors. Based upon these calculations, the data in Table 2-12 were generated. It is therefore estimated that approximately 9% of all injuries were suffered by white collar workers. Underlying this estimate is the assumption that Wisconsin injury experience is representative of the nation. The estimate is somewhat lower than previous estimates.

TABLE 2-12

Estimated U.S. White Collar Injuries

Occupational Classification	Reported Cases in Wisconsin	Ratio of Workers U.S/Wisconsin	Estimated U.S. Cases (1000)	Percent of Total
Blue Collar	39,049	47:1	1,835	74.0
Service	7,630	53:1	404	16.3
White Collar				
Adm/Man	1,070	50:1	53	
Prof/Tech	1,142	55:1	63	
Clerical	1,566	59:1	92	
Sales	621	36:1	22	
Farm	373	23:1	9	.4
Total	52,094		2,480	

As was pointed out in Chapter 1, only a portion of all white collar workers actually spend their time in traditional offices. Utilizing the estimates of office employment and the data from Table 2-12, adjusted injury frequencies were derived for white collar office employee. Since not all occupations within the white collar group experience the same injury rates, an attempt was made to adjust for this discrepancy as well. Two estimates are provided in Table 2-13. The first represents the number expected if all white collar occupations experienced similar rates and is considered to represent a maximum. The last column represents an adjusted estimate, determined by deleting injuries known to have occurred among occupations not considered to be office jobs. Both clerical and sales categories were found to contain a significant number of high injury occupations. As a result, the number of injuries estimated to occur among office workers is considerably reduced. The same was not true for administrative/managerial or professional/technical workers.

Based upon these estimates, approximately one of every 248 office workers suffered an injury. If these estimates are even close, it can be seen that the total number of injuries is quite small compared to other occupations, especially in consideration of the large number of office employees. As mentioned above, these figures certainly underestimate the total number of injuries by a large amount. In one of the few reports which included all injuries occurring in the offices studied, it was found that one of every 230 employees suffered a disabling injury while one out of 29 suffered an injury. The study involved the experience of one company (approximately 9000 employees) over a five year period (Baldwin, 1976). Based upon such information, the present estimates may represent only 12-13% of the total number of injuries suffered by office workers.

TABLE 2-13

Estimated U.S. Office Worker Injuries

Occupational Classification	Estimates Total Injuries (1000)	Total Adjusted for Percent of Office Workers (1000)	Total Adjusted by Including Only Office Occupations (1000)
Prof/Tech	63	25	24
Adm/Man	53	45	45
Clerical	92	78	58
Sales	22	11	5
TOTALS	230	159	132

Causes of Accidents

A number of safety hazards in offices have been identified. Some of the most common include: office machines, furniture, and walking-working surfaces. The majority of all falls occur on walking surfaces (slippery surfaces or objects in the way), followed by falls on stairs and from chairs. Office machines and furniture are the most frequent causes of injuries classified as "struck by," "struck against" and "caught in." Over-exertion injuries can be caused by moving objects or materials.

Control of Safety Hazards

Control of most office office hazards could be accomplished by utilizing well-established hazard recognition and abatement techniques. These include such things as guarding of pinch points and sharp objects, good housekeeping, and training. Unfortunately, most offices do not employ safety specialists or if they do, the specialist must be shared with other "more hazardous" occupations. Numerous training aids on the subject of office safety are available, however. Many existing OSHA and state safety standards apply to offices, although few offices are ever inspected. The Business and Institutional Furniture Manufacturers' Association (BIFMA) has developed consensus standards regarding many safety aspects of office furniture. The safe design of office machines is currently left to individual manufacturers and is therefore controlled primarily by market forces, product liability suits being one of the most powerful forces.

Radiation

With each of the previously identified potential hazards discussed in this chapter, the conclusion has been reached that sufficient evidence exists to indicate that the hazard may actually exist within office environments and thereby result in an increased risk to the health and well-being of office workers.

The same conclusion cannot be reached in the consideration of radiation as a potential hazard in offices. This fact does not, however, warrant the exclusion of any discussion of radiation, especially in light of the widespread concerns of office workers and public interest groups related to possible radiation emissions from VDTs. Industry and government officials have stated unequivocally that there is no evidence to indicate that VDTs are unsafe. While some would take exception to this statement, it appears that most would find it difficult to refute. The major issue can, therefore, probably best be summarized as a concern about what we do not yet know, because of a lack of sufficient information. Some would also contend that there may be relevant information that we have not been made aware of. It is argued that we cannot wait 20 years to find out that long-term exposure to low level radiation similar to that emitted by VDT is indeed hazardous, and that steps must, therefore, be taken to provide an additional margin of safety, especially in light of the large number of individuals who will be using such equipment.

Overview

One of the central issues of general public concern over the safety of VDTs has been the question of whether the machines emit harmful radiation.

This concern was first raised in 1977 when two workers at a major U.S. newspaper developed cataracts and the possibility of their connection to VDT work was raised (Zaret, 1980). NIOSH performed a health hazard evaluation and, based upon measurements of radiation emissions at the worksite, concluded that there was no convincing evidence to indicate that the cataracts were related to the use of the VDTs. Despite continued assurances from various federal agencies (Moss, et al., 1977; Murray, et al., 1981; BRH, 1981; Environmental Health Directorate, 1983), industry (Wolbarsht, et al., 1980), and employers (Weiss and Petersen, 1979; Weiss, 1983; Petersen, 1983) there remains a persistent and growing concern over the potential effects of radiation emitted by VDTs. Much of this concern can be attributed to reported clusters of birth defects and spontaneous abortions among VDT operators (Slesin and Zybko, 1983). Other fears can be traced to periodic reports of preliminary research findings concerning biological effects of certain types of radiation; concurrent controversies concerning other radiation issues; occasional reports of unusual levels of low frequency VDT emissions; controversy over the accuracy or adequacy of measurement techniques and instruments; and mistrust of those with vested interests.

Radiation is a general term used to describe the emission or propagation of energy from a source in the form of waves or particles. Such emissions are given off at some level by most electrical products. Electromagnetic radiation is arranged according to frequency in a continuum referred to as the electromagnetic (EM) spectrum (Figure 2-2). Radiation with sufficient energy to cause a neutral atom or molecule to acquire a positive or negative charge (become an ion) is called ionizing radiation and includes the beta, gamma and x-ray regions of the spectrum. The nonionizing portion includes the ultraviolet (UV), visible, infared (IR), microwave (MW), radio frequencies (RF) and

FREQUENCY IN HERTZ

10^{17} 10^{15} 10^{14} 10^{11} 10^{8} 10^{5} 10^{3}

<-IONIZING->|<----------------------NON-IONIZING-------------------------->

GAMMA AND X-RAY	ULTRA-VIOLET (UV)	VISIBLE	INFRARED (IR)	MICRO-WAVE (MW)	RADIO FREQUENCY (RF)	VERY LOW FREQUENCY (VLF)	EXTREMELY LOW FREQUENCY (ELF)
Medical X-ray	welding, lamps, heaters, sun			TV, radio transmiss., sealers, telephone communications		communicat. equipment	power line appliances

EXAMPLE SOURCES

FIGURE 2-2. The electromagnetic spectrum - Frequency boundaries, energy sources and designations.

static fields. The lower RF frequencies are also further subdivided into very low frequency (VLF) and extremely low frequency (ELF) ranges. The regions are not sharply delineated and emissions tend to occur both at specific emitted frequencies and at high and lower harmonics.

Radiation Measurements

Radiation levels from VDTs have been measured in both the ionizing and nonionizing regions of the electromagnetic spectrum. Measurements in the ionizing region indicate that under typical operating conditions emissions are usually near .01-.02 milli Roentgen per hour (BRH, 1981; Cox, 1980) or 1/25th of the current BRH television standard (.5 mR/hr) and amount to about 1/10th the maximum permissible yearly exposure for the general population assuming full time VDT work (2000 hr/yr). Levels due to VDT emissions in some cases were found to be below the detection capability of the ionizing radiation measuring instruments (no measurable difference from background level). Emissions in the ionizing portion of the EM spectrum are not considered to be a problem by government officials and appear to be of lessor concern to those raising questions about various types of VDT radiation at the present time.

Measurements in the ultraviolet, visible and infrared regions as well as within the microwave frequencies have also been carried out and found to be well below what are considered hazardous levels according to official U.S. standards and recommended levels. Measurements of emissions in the nonionizing portion of the spectrum have indicated that most of the energy is concentrated in the lower portion of the RF range (below .3 MHz), where no U.S. emission standards have been established. Since the biological effects of nonionizing radiation have traditionally been thought to involve thermal effects, and because these lower frequencies were thought to pass through rather than be absorbed by human tissue (based on calculations made from theoretical models), the consensus in the past has been that there is little or no hazard potential. Consequently, there have been no national standards established for frequencies below 300 kHz (.3 MHz). This year the American Conference of Governmental Industrial Hygienists proposed a level of 614 V/M or 100 mW/cm^2 between 10 kHz and 3 MHz. The American National Standard Institute recently revised its standard to make it frequency dependent and lowered the maximum permissible exposure for certain portions of the spectrum from 10 to 1 milliwatt/cm^2.

NIOSH is currently evaluating research across the entire EM spectrum for a criteria document. They are continuing to work under the assumption that specific absorption rates (SARs) (which have been criticized as being primarily reflective of only thermal effects) can adequately account for potential health effects (Glasar, 1979). This same line of thinking has also been responsible for the lack of interest in biological effects and the lack of comprehensive research efforts concerning low frequency radiation. Recently NIOSH has begun preliminary epidemiological research on the mortality among operators of radio frequency sealers which emit radiation in this portion of the EM spectrum. Indications are, however, that the NIOSH criteria document currently being prepared will not be able to address the low frequency issue. The fact that occasional studies report effects will no doubt keep the issue alive.

More recently questions have been raised concerning extremely low frequency (ELF) radiation from VDTs (Byrd, 1982; Brodeur, 1983). Measurements of ELF radiation emissions (1-500 Hz) from VDTs have been reported to be similar to those emitted by TV's and a variety of household appliances (Environmental Health Directorate, 1983) although actual user exposures have yet to be determined.

Since proponents of safety standards and safeguards for VDTs generally admit that VDT radiation emissions are low, one of the central questions which continues to generate interest and concern involves the potential effects of long term exposure to low level radiation. Exposure limits have been established for emissions over much of the EM spectrum, on the basis of available evidence of biological effects. As stated earlier, there are no applicable standards for comparison throughout the RF, VLF, and ELF regions where VDTs also emit radiation. In fact, there is very little research data available to help confirm or deny the existence of potential hazards associated with some of the types of radiation emitted by VDTs and other sources. One of the comparisons that is made to dispel fears is that VDT emissions are similar to or lower than other sources of radiation in the environment. While some would argue this point especially in consideration of total exposures, VDT field directionality, and user proximity to the source, the one point of agreement must be that questions relating to the potential effects of exposures to low level and specific types of radiations are much broader than the question of VDT safety. They extend to fields emitted by other office equipment (lights, copiers, heaters, facility wiring, etc.) and consumer products, as well as broadcast communications and power transmission technologies.

Radiation and Fears of Adverse Health Effects

The major fears of adverse health effects due to VDT exposures stem primarily from the previously mentioned incidental observances of ocular effects (cataracts) and reproductive effects (spontaneous abortions, miscarriages, birth defects) among VDT operators. Cataracts of potential radiant energy origin among operators of office type VDTs (approximately 10 cases) have been reported by Zaret (1980). However, independent evaluations of some of this medical data by NIOSH and other physicians have concluded that there is no evidence to indicate that the cataracts were related to VDT use (Marshall, 1981). Measurements from VDTs used by these individuals have revealed that levels of radiation at the frequencies currently thought to cause such effects were far below the level conventionally considered necessary to produce cataracts. The results of surveys of Canadian workers (CLC, 1982) and newspaper workers (Frank, 1983) have revealed no increased reports of cataracts among VDT operators. A NIOSH study which included comprehensive ophthalmological examinations found no association between cataracts and VDT use, although it was pointed out that long term exposure effects could not be evaluated due to the limited exposure of the population studied (Smith, et al., 1982).

There have also been some reports of health effects from other radiation sources such as power lines (Lerner, 1980; Slesin, 1983). Such claims suggest nonionizing radiation, at least in part, rather than physical and mental demands alone may be a contributing cause of observed health effects such as eyestrain, fatigue, headaches, psychological disturbances, and chronic disease. These concerns are largely conjectural, however, and are considered premature due to the low levels of radiation emissions. Furthermore, as indicated in other sections of this report, the results of studies comparing VDT users and nonusers with respect to these types of complaints are equivocal. On the basis of available data, ergonomic problems and job demands appear to be more plausible etiological factors.

It is extraordinarily clear, however, that VDT operators in the U.S. and Canada (especially pregnant workers) are very concerned. The National Association of Working Women, which recently provided an 800 number that individuals could call to obtain information relative to VDTs, reported receiving

500-1000 calls per week during the first month (Gregory, 1983). The most frequently asked questions concerned vision, and the second most frequent were those related to possible reproductive effects. While there is no clear objective evidence to support such fears, they are nonetheless very real and widespread. In Canada, at least ten different employers have reportedly conceded the right of pregnant VDT operators to transfer to non-VDT work during pregnancy and a number of U.S. companies have reportedly made similar concessions. These actions by employers are affected to some degree by the lack of access to clear information on the subject, fears of liability claims, and some measure of prudence. Some employers have indicated that while they felt confident that no radiation risk existed, the stress related to such fears was indeed very real and was, in fact, the primary reason for allowing such transfers under currently existing contract provisions. This policy often serves to reinforce the fears of workers and their mistrust of studies. The Labour Canada Task Force on Micro-Electronics and Employment adopted a similarly conservative stand:

> "Any number of social and environmental factors ... might be the cause of the clusters of miscarriages and birth defects reported form some VDT worksites. However, until more conclusive epidemiological research studies completely rule out VDT(s) as a hazard to the fetus, the Task Force urges a precautionary approach. We recommend that a work standard be adopted that gives pregnant VDT operators the right to request and be granted reassignment to another position without loss of pay, seniority or benefits." (Labour Canada Task Force, 1982, p. 54).

The Canadian Labor Relations Board recently rejected the request of a pregnant VDT operator for alternative work, however (Microwave News, 1983).

The economic and psychosocial impacts on employers and workers which might arise out of the proliferation of pregnancy transfer policies can be well appreciated if one recalls the issues surrounding the promulgation of the lead standard.

It is also very clear that radiation measurement studies of VDTs will not solve this problem, nor will radiation monitoring of VDT workplaces.

Control Technologies

The question of control technologies and methods must address several issues including the nearly epidemic proportions of fear among pregnant VDT operators. Three basic alternatives are thus available: (1) conduct research which will assess the risk of VDT operators especially as related to reproductive effects, (2) reduce radiation emissions from VDTs, and (3) provide education and training for users. The first would appear to be the most important since the efficacy of reducing emissions depends upon whether a hazard exists and it is impossible to estimate how low emissions would have to be in order to alleviate concerns. Nevertheless, it is argued that where reductions in exposures are reasonably attainable, experience with other agents has proven the value of this approach, especially when uncertainties exist. The effect of the third is uncertain.

Research. It would appear that the most immediate need is for a large scale epidemiological study of VDT worker health. The Reproductive Hazards branch of NIOSH is currently conducting a feasibility study in an attempt to determine whether such a study should be conducted, and if so, how it would have to be done (Gordon, 1983).

Due to the complexity of studying radiation effects, laboratory research does not appear to offer a feasible approach to dealing with the issue of fear of radiation.

Standards. Standards for comparison of VDT emissions are available in the ionizing, ultraviolet, visible, infrared, microwave, and radio frequencies (down to 300 kHz). There are no such standards for any of the radio frequencies below 300 kHz including the very low and extremely low frequencies.

The standards of comparison often used in these ranges are the background level or other sources of exposure--the argument being that VDTs constitute a relatively small proportion of any potential risk which might exist. While this comparison may influence public policy decisions, it does not address the question of whether there is in fact a risk associated with these types of radiation, especially over long periods. Due to the scarcity of research data related to many types of radiation in the low frequency range, it is unlikely that safety standards will be established in the near future. It is also unlikely that the establishment of standards will do any more to alleviate concerns than do existing standards.

Testing of VDTs. FDA's Bureau of Radiation Health currently has statuatory authority to require testing through performance standards for certain VDT product manufacturers (but not users) under the Radiation Control For Health and Safety Act of 1968 (Public Law 90-602) charging FDA with protection of the public from unnecessary exposure to ionizing and nonionizing radiation from electronic products. This authority also allows BRH to require corrective action by manufacturers. However, FDA-BRH has not promulgated specific performance standards for VDTs nor have they solicited emission data from VDT manufacturers. Some VDTs, that is those which can be used in TV applications, are currently subject to existing standards for TV receivers. These standards are limited to coverage of ionizing radiation. BRH has developed and published measurement protocols for all but the ELF and VLF portions of the EM spectrum (BRH, 1980).

Health researchers are interested in the radiation dose absorbed by an exposed individual. No nonionizing radiation dosimeters are yet available.

Currently, instrumentation capabilities allow only measurement of emissions from VDTs, that is the quantity of radiation given off by a terminal. Determining absorbed dosage from emission measurements is complex and inexact, involving mathematical considerations of factors such as body angles, directions, shapes and field distributions.

In view of the fact that certain cathode ray tube products (including oscilloscopes, TVs and VDTs) that have reached the market in the past have been found to emit significant levels of ionizing radiation (Weiss and Petersen, 1979; BRH, 1981), it appears obvious that regulations or performance standards such as those currently administered by FDA play an important role.

While field testing for radiation is the only way of determining the actual exposure of a worker, it is difficult and expensive. The value of such testing is questionable. Previous testing has, in all cases, indicated that, according to present safety standards, no hazard exists. Such field testing has also done little to quell widespread concerns.

Education. It is very clear that more and better education and training of both employers and employees concerning radiation is necessary. As pointed out above, efforts to date have been less than successful. It is, however, difficult to determine what the impact of training and education will actually be, especially because of the nature of the subject matter. The complications created by the necessary distinctions between emissions, exposures, doses and specific absorption rates; different regions of the electromagnetic spectrum and their respective units of measurement and biological effects; near-field vs. far-field; and instrumentation and methods of measurement, make the subject of radiation virtually incomprehensible to laypersons. The level of confusion which can be experienced by one attempting to evaluate VDT-related radiation studies is examplified in Table 2-14 which indicates the variety of units of measurement utilized and the location at which measurements have been recorded. Evaluation of the risks associated with radiation exposure must be carried out by experts. The success of any education or training efforts will, therefore, depend, to a large extent, upon the credibility of such experts and the degree of concensus between them.

Other Control Methods. Other techniques are available which could potentially reduce radiation emissions including increased shielding and different display technologies such as thin film electroluminescent.

Some public interest groups and labor organizations have advocated such control methods based primarily on the belief that even very low radiation emissions will eventually prove to be hazardous and added precautions are therefore justified. The counter argument by industry has been that VDTs already emit less radiation than numerous other devices in both work and non-work environments, and therefore any further reduction would have little if any impact on total exposure.

TABLE 2-14

Units and Locations of Radiation Measurement Reported in VDT Studies

Electromagnetic Field	Units	Location at Which Measurements Were Recorded
Ionizing	mR/h	
	micro R/h	
Ultraviolet	W/m^2	
	W/cm^2	
	W/cm^2 sr	
	micro W/cm^2	
Visible	fL	
	W/m^2	- 5 cm from screen
	W/cm^2	- at operator position
Infrared	W/m^2	- 30 cm from screen
	W/cm^2	
		- screen surface
Microwave	V/m	
	V^2/m^2	- position of maximum reading
	W/m^2	
	mW/cm^2	- at back yoke
Radio Frequency		- 10 cm from side
Electric	V/m	- top
	V^2/m^2	
	mW/cm^2	- back
	W/m^2	
Magnetic	A/m	
	A^2/m^2	
	m W/cm^2	
Extremely Low	A/m	

CHAPTER 3

RELATED TOPICS

Concerns and Activities of Interest Groups

The following section provides a brief summary of typical interests and activities of different organizations which have particular interests or roles in the issue of office health and safety. It appears safe to conclude that a central concern of all or most of these groups is the video display terminal issue. Four categories of interest groups will be considered: (1) employees, (2) employers, (3) manufacturers, and (4) government. In addition, foreign activities will be discussed. Some of the activities described below as representative of one group may overlap with others.

Employee Interests

One of the most active, vocal, and visible groups currently involved in office worker safety and health issues has been 9 to 5, National Association of Working Women. This non-profit organization currently has 17 local affiliates around the country and 12,000 members. The organization is also affiliated with the Service Employees International Union, District 925 which has a membership of 4,000. While a major concern of Working Women has been upgrading clerical jobs and fighting sex discrimination policies and practices, the organization has been actively involved in issues related to safety and health in the office. These activities have included organization and participation in conferences and workshops on office health issues, publication of numerous materials, and surveys of office workers. The basic philosophy of the group is to alert, educate and organize office workers to improve working conditions.

A number of labor unions have been involved in office work issues to varying degrees. In 1979 only 6.5% of those classified as clerical workers were organized. More than 40% of the unionized workers were in the public sector, and only 1.5% of the insurance industry was unionized. Although many more unions have been directing their organizing efforts toward white collar workers, they still do not represent a large percentage of the membership of most unions. Only 9 unions have more than 50% of their membership in clerical occupations. Approximately 25% of all professional and technical employees belong to unions or associations (Kilgour, 1983). Some of the major unions which include significant numbers of office workers are:

- American Federation of Government Employees (AFGE)
- American Federation of State, County and Municipal Employees (AFSCME)
- Communications Workers of America (CWA)
- Brotherhood of Railway and Airline Clerks (BRAC)
- International Brotherhood of Electrical Workers (IBEW)
- International Brotherhood of Teamsters (IBT)
- Insurance Workers International Union (IWIU)
- International Association of Machinist and Aerospace Workers (IAMAW)
- Office and Professional Employees International Union (OPEIU)
- Service Employees International Union (SEIU)
- Telecommunications International Union (TIU)
- The Newspaper Guild (TNG)
- United Steelworkers of America (USWA)
- United Auto Workers (UAW)
- United Food and Commercial Workers (UFCW)

Activities have typically included the following:

- Development of manuals on safety and health for office workers,

- Development of manuals on VDT related problems,
- Training programs for members (VDTs, health problems, stress, ergonomics),
- Participation by staff in office health, stress and VDT workshops and seminars,
- Support of state legislation related to VDTs,
- Sponsorship and participation in research,
- Development of proposals for collective bargaining.

Most unions include some type of language in their contracts concerning safety and health, and a few have specific language dealing with office technology and VDTs.

Employers

While numerous employers have been devoting more effort to dealing with safety and health hazards for office workers (usually related to VDTs), there has been very little activity by employer organizations. The threat of legislation in various states will undoubtedly change this situation. For example, the Associated Industries of Massachusetts recently held a meeting for New England area industry associations to develop strategies concerning legislation.

A number of consensus standards committees are currently active in areas related to office safety and health. While these are not exclusively employer organizations, they do tend to be dominated by management.

Manufacturers

The most prominent manufacturers association is the Computer and Business Equipment Manufacturers Association (CBEMA). This organization represents manufacturers of computers, data processing, office equipment and supplies. The organization has about 40 members representing approximately 85% of the industry. One of the organization's current interests involves the issue of VDT safety. CBEMA activities include: the establishment of committees on environment, health and safety, and human factors; participation in legislative hearings; participation in standards setting groups; and publication of informational materials. A similar organization including many of the same members operates in Europe (European Computer Manufacturers Association [ECMA]).

Other manufacturers' organizations with a potential interest in office health and safety issues include the Business and Institutional Furniture Manufacturers Association (BIFMA) and the National Office Products Association (NOPA). Each organization represents substantial portions of the furniture and office products industries.

BIFMA activities have been concentrated primarily on the development of concensus performance standards for office equipment. A total of six standards and test procedures have been developed to date addressing such things as durability, stability, strength, flammability and safety of chairs, desks and file cabinets. One of BIFMA's primary function is serving as an information resource for its members and outside market demands. Standing committees include:

1. Engineering Standards Committee
2. Information Systems Committee
3. Communication and Industry Liaison Committee
4. Education Committee
5. Governmental Affairs Committee

BIFMA has over 100 members representing 90% of the industry's sales volume.

NOPA has funded a major study concerning trends in office environments. While a principle objective of the initial research was forecasting industry trends, preliminary reports have placed a heavy emphasis on the importance of office design and office equipment in determining worker comfort, health and productivity.

The Chemical Manufacturer's Association (CMA) has supported a proposed OSHA "Hazards Communication Standard" which excludes most office workers.

Government

The National Institute for Occupational Safety and Health bears the primary responsibility for conducting research and developing information concerning office health and safety. Relevant activities to date have included research, literature reviews, publications, seminars, training programs and health hazard evaluations. Some of the recent NIOSH activities are described below:

- Contract with a university to investigate effects of VDTs.
- Contract with a university to investigate visual effects of VDTs.
- Development of a training program and manual on VDT health problems.
- Literature reviews on stress factors in office and clerical work and VDT problems.
- Health hazard evaluations related to stress, air quality and VDT problems (radiation, ergonomics, stress, health).
- Internal research related to stress, VDTs, ergonomics.
- Sponsorship of several conferences on clerical/secretarial health issues.
- Development of a criterion document on radiation.
- Sponsorship of a National Academy of Science study of visual effects of VDT work.

Occupational Safety and Health Administration (OSHA). OSHA has not been actively involved (at least at the national level) in any of the issues relating to office hazards. A recently promulgated "Hazard Communication Standard" only covers those working in manufacturing industries.

Bureau of Radiological Health (BRH). BRH activities have included investigation of radiation emissions from VDTs in laboratory and field settings, as well as intramural and extramural research on radiation.

Environmental Protection Agency (EPA). EPA sponsored a major study of indoor air quality which included information concerning air quality in buildings. Few specific studies of offices have been conducted. EPA is working on a general population standard for exposure to nonionizing radiation.

State Government. Activities at the state level include VDT bills which have been introduced in seven different states. In two of these states, the issue has resulted in the establishment of committee or technical studies. No legislation has been passed. As of the Fall of 1983, thirteen states had passed "hazard communication standards" or "right to know" legislation. It is uncertain whether the recently published federal standard can preempt these stricter state standards.

International Activities

Activities related to office hazards in foreign countries have generally been concerned with new technologies and usually limited to VDT issues. Some of the earliest activities were studies conducted by the Technical University of Berlin for the German Government and an Austrian Trade Union Council study on video display terminals. Australia promulgated a general ergonomics standard which applies to offices in 1976. In France, a seminar on visual problems related to VDTs resulted in a 1977 report and the formation of a study groups. In 1978, the results of the Technical University of Berlin study were published and eventually formed the basis for the widely distributed VDT Manual (Cakir, et al., 1980). The recommendations also formed the basis for the German DIN standard which will take effect in 1985, specifying certain image quality and equipment adjustment requirements. In 1978, the Swedish Board of Occupational Safety and Health (SYNBOSH) issued a national directive concerning the reading of visual display screens. About the same time, the Defense and Civil Institute of Environmental Medicine prepared specifications to aid the Canadian Federal Government in selecting VDTs for federal employees. In 1980, a report describing the results of a study conducted by the New Zealand Department of Health were released.

The Norwegian Labor Inspectorate's Directorate for Work Councils issued regulations and guidelines for VDT use under the Work Environment Act. Two reports were issued almost simultaneously in 1982 by the Canadian Labour Congress (CLC) and a task force of the Canadian Government. The CLC study included the results of a survey and both reports included recommendations for VDT use. The Canadian Government Task Force report was the first case in which a government-related group suggested pregnancy leaves for VDT operators. Provincial governments in both Ontario and British Columbia have considered VDT legislation. The Australian Council of Trade Unions adopted a comprehensive safety and health policy on screen based equipment in 1982 and is currently attempting to negotiate agreements with major employers.

In 1983, the International Standards Organization met to consider the development of an Ergonomic Standard for VDTs. Proposals were submitted by Norway, Great Britain and France but no action was taken. Working groups were established and the next meeting is scheduled for late in 1984. Due to the normal time delays in developing standards, no ISO standards could be expected until at least 1986.

Standards Activities Related to Office Hazards

Standards, regulations and guidelines directed at controlling office safety and health hazards have been most apparent in Europe. Germany, Norway and Sweden all have adopted various types of standards, rules or guidelines relating to VDTs. Similar activities are underway in Great Britain.

At least two Canadian Provinces have considered legislation and the national government has expressed an intention to further consider the need for legislative control. As of this time, none have been adopted.

In the United States, such legislative efforts have been limited to the state level. The only federal government involvement to date has been a set of guidelines prepared by NIOSH and first published in 1980. At least seven states have considered VDT legislation and the activities of a variety of public interest groups suggest that similar legislation will be introduced in a number of other states.

Most of the proposed state standards have been modeled after European regulations and have generally dealt with ergonomic factors, VDT design, rest breaks, restriction on maximum use, visual exams, and pregnancy transfers. These activities are summarized in Table 3-1. As of this date, no legislation has been passed regulating VDT use, although two states (Connecticut and Maine) have passed bills requiring studies of related issues.

An American National Standards Committee (ANSI) was recently formed to prepare voluntary consensus standards dealing with ergonomics. Other standards activities in the U.S. which may have a potential impact on office

TABLE 3-1

Proposed Legislation Addressing Office Equipment Health and Safety

Governing unit	Requirements						Current status	Other stipulations
	Vision exams	Pregnancy transfer	Adjustable equipment	Rest minutes per hour	Hour limit per day	Hazard communication		
Connecticut			*	20/2 hr		*	Technical Study	glare guards, character size, heat exhaust, radiation monitoring and research
Illinois	*		*	15/2 hr		*	Tabled	
Maine	*			15/2 hr		*	Study	semiannual VDT maintenance, state agency work rules authorized
Massachusetts	*	*	*	15	5		Proposed Study	copystands, work redesign, surveillance notification, stress red
New York	*	*	*	*	*		Bill Introduced	radiation protection jackets dropped
Oregon	*	*	*	30/2 hr		*	In Committee	glare guards, local light, env. light, VDT maintain, no work end of shift-30
Ohio	*	*		*	*		Bill Introduced	glare reduction, metal shielding, restrictions on performance measurement
Washington	*	*	*	*		*	Rule Making	

hazards include state and federal legislation concerning the labeling of hazardous materials and providing information to users ("right to know legislation") and some activities related to radiation. An ANSI standards committee has been attempting to revise the old occupational exposure standard to make it frequency dependent and more stringent for certain portions of the spectrum (30-300 Mhz) and less stringent in the higher (1500 Mhz-100 Ghz) and lower frequencies (300-Khz-3 Mhz). NIOSH is currently preparing a criteria document on radiation.

A number of states and cities have passed general population standards for radiation exposure.

Virtually all states have local standards and codes relating to buildings (e.g. ventilation, lighting, temperature), although most are merely design standards.

Relationship Between Office and Non-office Hazards

Consideration of the potential adverse effects of office hazards described, as well as control technologies and policy strategies should be viewed in relation to their potential impact on other non-office exposures. Much of the discussion has concentrated on clerical workers, who represent the largest percentage of office workers, since they would appear in most cases to experience the highest risks. There are a number of unique characteristics of this group of workers which differentiate them from other work groups:

- the majority are women
- most receive low pay
- opportunities for advancement are minimal
- few belong to labor unions

These characteristics could affect the widespread applicability of policies and strategies developed to control office hazards. Nevertheless, there are some obvious implications which deserve consideration.

- The general question concerning the potential long term effects of low level exposures to radiation and air pollution has an impact on virtually all members of the work force.
- The effects of microelectronics technology and automation have already had a substantial impact on large groups of workers within all sectors of the non-agricultural work force. Issues such as job displacement, machine control and monotonous work have already surfaced in a variety of non-office occupations. Video display terminals will become more common throughout all workplaces, as well as homes and schools. Although there uses may differ, equipment design problems, intensive visual demands, and other ergonomic features will be factors which may be common to all.
- Stress appears to be one of the most inherent commonalities between different occupations. While different factors may contribute to stress in different jobs, control strategies developed within the office setting (e.g. job redesign, worker participation, job control) would undoubtedly prove to have widespread implication for non-office workplaces.
- Ergonomic approaches to hazard control have had relatively little impact within other sectors of the work force. The recent attention given to designing office equipment based upon ergonomic principles could accelerate the trend toward designing work to fit the worker.

CHAPTER 4

STRATEGIES FOR CONTROLLING HAZARDS

In order to reduce hazards, two considerations are essential. The first involves the recognition and identification of hazards and the development of specific control technologies which serve to abate these hazards. The second consideration involves developing public policies or strategies which assure that hazard control actually is carried out. The variety of hazards which potentially exist in office environments have been described in previous sections. For each hazard, an attempt was made to analyze the level of risk based upon typical exposures and number of individuals exposed. In addition, different control technologies which might serve to abate these recognized or potential hazards were presented and evaluated in terms of their effectiveness and costs for each of the hazards. Table 4-1 serves to summarize briefly the analysis of potential hazards, sources, and potential control strategies which have been described. The control technologies fall into the following categories.

1. Engineering Controls. Through the use of engineering controls, the sources of hazards are physically reduced or eliminated. This may be accomplished by redesigning equipment (better design of equipment such as VDTs, ergonomic design of office furniture, providing adequate ventilation, enclosing air contaminant or noise sources, controlling illumination); or removing or substituting less hazardous materials, equipment, etc. (e.g. chemicals in office products, selection of better designed furniture or VDTs).

TABLE 4-1

Hazard Control in Offices

	Potential Health Effects*	Potential Hazards	Hazard Control
Air quality	Irritation, discomfort, outbreaks of disease, sensitization	Formaldehyde, ozone, organics, allergens, micro-organisms	ventilation, substitution enclosure, filtering
Temperature	Discomfort	Heat, cold, humidity, air circulation	radiant control, air circulation, different location, individual control, humidity control
Musculoskeletal Stress	Neck, shoulders, back, arms fatigue and chronic disorders	Workstation design, chair design, task repetitiveness, constrained posture	Furniture ergonomics, task redesign, job enlargement, rotation, rest breaks, exercise
Visual Stress	Eyestrain, burning or itching	Lighting, close work, quality of VDT and other viewed material, dry air, stress	Vision exams, illumination controls, equipment design, rest, exercise, work layout
Psychologial Stress	Anxiety, tension, stress, boredom, headaches, job dissatisfaction, alienation, absenteeism, turnover, behavioral problems (smoking, drinking), ulcers, CHD, diabetes and other diseases	Repetitiveness, monotony, monitoring, lack of promotional opportunity, lack of job security, lack of control, pacing, piecework, work environment	Stress management, wellness, exercise, job redesign, worker control, job enlargement, job enrichment, rotation, environmental control
Noise	Irritation, interference, distraction	Conversations, equipment, ventilation systems	Barriers, equipment design, enclosures, absorption
Accidents	Traumatic injuries	Work surfaces, furniture, equipment, lifting	Guarding, hazard removal, training

*Almost all potential hazards may affect health indirectly by causing emotional stress, especially air quality, temperature and noise.

TABLE 4-1
(Continued)

	Potential Health Effects*	Potential Hazards	Hazard Control
Radiation	None yet established	Low level radiation	Shielding, low voltage, alternative designs, work removal, time limits

*Almost all potential hazards may affect health indirectly by causing emotional stress, especially air quality, temperature and noise.

2. Administrative Controls. Hazards may also be controlled by implementing certain changes in administrative procedures. Examples include removing individuals from sources of hazards, rotation to less hazardous or less stressful duties or work areas, smoking restrictions, medical surveillance, work-rest schedules, and job enrichment.

3. Behavioral Methods (Personal Control). In situations where the feasibility of controlling certain hazards is questionable (especially in cases where individual differences play a major role or when exposure is brief), certain behavioral approaches may be useful. These include training (e.g. handling of materials, adjustment of equipment, adjustment of lighting, operating procedures, type of clothes to wear), exercise to relieve discomfort, and stress management techniques.

The identification of hazards and hazard control techniques obviously does not assure abatement. The second step involves informing employees, employers, and manufacturers. The third step involves providing sufficient motivation to assure that hazard abatement is actually carried out. All three steps require the development of public policies or strategies for implementation. The remainder of this chapter provides a discussion of alternate strategies as they relate to the control of office hazards.

The moral, legal and economic issues surrounding the development of public policies have been addressed in relation to a variety of work related hazards in the past. The same arguments obviously apply to the control of hazards in offices. Two of these arguments are especially pertinent to the consideration of office hazards and relevant control strategies. First of all, public debate on occupational safety and health issues seldom has successfully gone beyond the issue of demonstratably physical impairment. In view of the nature of most of the office hazards considered, the clear demonstration of physical impairment is often difficult. At the same time, it is clearly evident that the concerns of office workers encompass a much broader definition of impaired health which includes at least freedom from psychological distress and pain. The need for a broad definition of occupational health and safety has been debated on both philosophical and scientific grounds.

The objectives of occupational health, as defined by the International Labour Organization and the World Health Organization (1963), include "... the promotion and maintenance of the highest degree of physical, mental, and social well-being of workers in all occupations; ..." The philosophy behind the American Conference of Governmental Industrial Hygienists' threshold limit values is as follows:

> "The basis on which the values are established may differ from substance to substance; protection against impairment of health may be a guiding factor for some, whereas reasonable freedom from irritation, narcosis, or other forms of stress may form the basis for others." (ACCIH, 1983).

Even if irritation, pain, and distress are not considered as manifestations of impaired health, it can be argued that they are often significant precursors of impending impaired health. For example, psychological distress may lead to ulcers or coronary heart disease.

The second problem concerns the specific issue of establishing permissible exposures. Whereas initial decisions are generally made based upon scientific knowledge, compromise has usually been sought (with few exceptions) at some level which reduces exposure to a level of "acceptable" or "reasonable" risk based not only upon scientific knowledge but also upon economic and technological considerations. As a result, permissible exposure levels (especially when legislated) generally do not provide safety margins for protection against potential unknown long-term effects, synergistic effects, aggravation of pre-existing conditions, or hypersensitivity.

It is evident that any policy which is developed without giving adequate attention to these issues will fall short of a satisfactory outcome in the eyes of concerned office workers.

Alternate Strategies For Implementing Office Hazard Controls

There are four approaches generally employed, individually or in combination, in efforts to reduce safety and health hazards: (1) regulatory activities; (2) information generation, dissemination, and utilization; (3) market incentives; and (4) manpower development. The particular mix of strategies employed in comprehensive public policy approaches to the reduction of technological hazards in the U.S. have most often stressed the first approach.

Regulatory Activities

Regulatory control of hazards includes the legislation and administrative rules developed to establish limits, standards, guidelines, product specifications, compliance methods, enforcement procedures and penalties in order to attain safer exposure levels, insure healthful work practices, prohibit unsafe products, or otherwise protect those persons potentially at risk. Regulations providing certain rights to workers and their representatives have also been included in recent U.S. legislation, and some European countries have extended the rights of workers to include local control over hazards.

Advantages and Disadvantages of Regulations. The basic argument used by employee groups and organizations in support of regulations is that nothing will be done unless employers are forced into action. Standards provide employees with an essential tool which can be used to force employer action to reduce hazards. While the collective bargaining process provides an alternative, only 25% of all workers are organized and only 8% of the white collar work force is organized. Collective bargaining is, therefore, not a reasonable alternative in this case. While employers and manufacturers naturally oppose regulation, there are situations in which they do provide certain advantages. That is, compliance with a standard may reduce liability or protect the employer or manufacturers. For example, VDT manufacturers and employers have pointed out that radiation emissions are well below existing standards. In other cases, employers may be unsure of what to do. A standard may thus provide specific and definable goals.

The most often cited disadvantages of regulations include:

- Manufacturers and employers may be satisfied with only meeting the requirements of the law, thereby preventing or reducing the possibilities of reducing exposure below prescribed levels.
- Regulations interfere with workplace relations, polarizing attitudes.
- Regulations restrict the use and benefits of new technology.
- Regulations may require certain activities in spite of the lack of any evidence of adverse health effects, thereby imposing unnecessary economic burdens.
- Regulation may adversely affect productivity.
- Regulations tend to stagnate and not adapt to new hazards and control technologies.

Determining Safe Exposures. The establishment of specific exposure limits or design requirements demands that sufficient information be available concerning the causal relationship between exposure and health effects. Even in those cases where direct relationships are established (e.g. noise, lead, asbestos), the establishment of a particular level usually represents a compromise based upon limited knowledge and economic and technological feasible. Virtually all of the hazards described in this report face this difficulty. Ergonomic and stress related problems do not easily lend themselves to the application of specific standards because of the lack of unequivocal information relating specific exposures to adverse health effects. The lack of adequate information concerning the long term effects of the low level exposures characteristic of radiation, air contaminants, and noise present similar problems.

Product vs. User Standards. Product standards may be imposed by requiring that manufacturers meet certain standards or that adequate information be provided concerning the hazards associated with use of the product. One of the principle advantages of product standards is the relative ease of enforcement compared to standards imposed on users or employers. For example, one can contrast the feasibility of imposing a design requirement on approximately 150 VDT manufacturers versus field testing in excess of 10 million terminals. When recognized hazards and control methods are available, inclusion of hazard control technology during production is less expensive than retrofitting. At the same time an unnecessary cost may be imposed if a hazard does not exist in the workplace because of the nature of use. Product standards also fail to control products already in use. While warnings and labeling do not assure the safe use of products, they do provide concerned users with valuable information which can be helpful in selecting control strategies. Product standards would also be applicable to only some of the potential hazards which might exist in offices.

Design vs. Performance Standards. Design standards specify exactly what and how control of a hazard must be accomplished. A performance standard only establishes what must be accomplished. Performance standards may occur in two forms. The most common is represented by a threshold limit value (e.g. noise and air contaminants). Less common are standards which simply require that recognized hazards be eliminated (e.g. "general duty clause" section 5(a)(1) of the Occupational Safety and Health Act, 1970).

Performance standards are usually favored by manufacturers and employers since they allow freedom in selecting the most efficient method of meeting the requirements of the standard. In some cases, design standards are easier to accomplish, however, especially where they eliminate the necessity for expensive testing. Unions have usually supported design standards for the same reason (i.e. it is much easier for workers to determine whether specific design requirements have been met than to measure exposure levels). Design standards are, for the same reasons, easier to enforce by regulatory agencies.

A major disadvantage of design standards is that they may not guarantee a safe level of exposure. For example, as was indicated in Chapter 2, ventilation requirements for buildings are usually based upon design standards. In many cases, once in operation the systems are found to perform at levels far below design expectations. Design standards also impose restrictions where no hazard exists. For example, required glare shields and detachable keyboards for VDTs may be unnecessary in some environments or with certain limited uses.

Engineering vs. Administrative Controls. Engineering controls are generally preferred because they reduce or eliminate the source of exposure. In other cases, there may not be any feasible engineering controls and administrative procedures such as rotation, rest breaks and removal from the source of exposure may be necessary. Administrative controls may lead to discriminatory practices due to age, sex, handicaps or hypersusceptibility. Administrative controls are often complicated by collective bargaining agreements which specify job values, rest breaks and job duties.

State vs. Federal Regulation. All interested parties have generally been in agreement (although for different reasons) in favoring federal regulation over state regulation. Notable exceptions have, however, occurred recently concerning hazard communication ("right to know") legislation and proposed VDT legislation. In the first case, labor and public interest groups have supported stricter state standards and, in the second case, have supported state standards because of the lack of any anticipated activity at the federal level.

Feasibility and Effectiveness of Regulation. Several obstacles can be identified which would cast doubt on the effectiveness of regulatory activities to control office hazards.

(1) Federal and state compliance activities are already grossly overburdened. Before recent cutbacks in budgets and staffs, it was already projected that each business might expect to be visited only once in several years. Many local jurisdictions have chosen to target certain high hazard industries. It is questionable, therefore, whether limited inspection forces could or would be redirected toward offices where very limited evidence of serious risks in comparison to construction and manufacturing industries exist. While complaint avenues would be opened up, even these procedures have been seriously restricted by personnel limitations and policy directives.

(2) The effectiveness of regulatory activities are also questionable in view of the record for standard setting procedures as is witnessed by the limited number of revisions and new standards promulgated in recent years. Standard setting procedures in the United States have not established a precedent for the development of over-protective or prudent regulations that would be required for virtually all of the office hazards described.

(3) Many of the hazards encountered in offices do not easily lend themselves to control through standards. Most notable are ergonomic and stress related problems. Both are highly dependent upon local environmental conditions, the nature of the job, and management styles.

Standard Setting Activities. While standard setting activities have been pursued in a number of foreign countries, activity in the U.S. has been limited to the state level. These activities have been summarized in Chapter 3 of this report. Proposed state legislation has been criticized by computer and business equipment manufacturers because it addresses only VDT work. This is generally true and is an important consideration in evaluating the potential effectiveness of any state regulatory activity in controlling office hazards.

Table 4-2 includes a brief overview of some hazard specific considerations related to regulatory activities.

Generation, Dissemination and Utilization of Knowledge

Information is the crucial currency involved in the solution of all occupational health and safety problems. Generation of knowledge refers to research activities which provide the data base concerning the nature of

TABLE 4-2

Considerations Related to Regulation of Office Hazards

Potential Hazards	Considerations
Air Quality	Lack of data available on long term low level effects prevents development of standards. In order to provide a level of protection adequate to prevent irritation, discomfort, sensitization, and protection for hypersensitive individuals, threshold levels would have to be much lower than currently established levels. Ventilation performance standards would prevent many current problems and provide better protection than current design standards. Measurement of performance would be difficult for most offices without outside assistance.
Temperature/Humidity	Current performance standards exist in most local building codes, however, they do not address zone temperatures (thermostat setting is the only consideration). While it is clear that closer regulation of standard temperatures, humidities and ventilation rates would improve temperature comfort for a substantial number of individuals, it is unclear how many individuals would still experience problems due to varying comfort ranges.
Musculoskeletal problems	The lack of clear data indicating the relationships between specific design factors and musculoskeletal problems makes legislation difficult. Requirements for adjustable workstations (chairs, tables, layout) would help a substantial number of people. However, many improvements can be made without extensive user adjustability built into furniture, and at a lesser cost. While performance standards would therefore, be more desirable, they would also be much more difficult to enforce since the worker would have to prove that the equipment was responsible for problems. Likewise, job design factors (rest schedules, task variation, etc.) are not easily amenable to design standards due to variations in job demands.

TABLE 4-2
(Continued)

Vision problems	While certain design standards related to image quality and illumination are potentially realistic, more data relating effects to causes is necessary. Design standards for visual demands could be established for certain highly demanding or repetitive tasks based upon currently available data. Defining the lower limit of "high visual demands" would, however, be difficult as would evaluation of specific jobs. "Vision conservation" programs including periodic eye exams could be developed, although specifying the exposure level at which evaluation would be required would be difficult.
Stress	Stress, due to the broad scope of stress and the difficulty of measurement, does not easily lend itself to traditional forms of hazard control legislation. Several European countries have developed worker involvement and job enrichment types of legislation.
Accidents	A number of current state and federal standards apply to offices. Examples include electrical, fire protection, and building codes; and standards for working surfaces and machine guarding. Due to the relatively low rate of accidents in offices, inspections are rare, however.
Noise	While maximum noise exposure levels could be established for office work, it would be difficult to define and measure irritating and distracting noise, in other than the broadest terms.
Radiation	Current standards exist for much of the electromagnetic spectrum. There are no standards for certain frequencies in the non-ionizing region, and there is very little data concerning risk in this region, making standards setting difficult. Long term effects of low levels are not well established. Field enforcement would be very difficult, and product performance standards would appear to be the only feasible control available, should the need for standards be established.

hazards, control strategies and technologies. Dissemination of knowledge or information access is provided by publication of technical information in useful forms and in a timely fashion. Utilization of knowledge includes demonstration projects, educational programs, and training activities that apply available information to the development of human skills and abilities.

Many of the most basic questions about occupational health and safety hazards remain unanswered. These shortcomings are not surprising in light of historical failures to recognize occupational contributions to health, and the rapid pace of technological implementation in the workplace. The result is a tremendous backlog of research work that has only recently been acknowledged. The long period of neglect in health and safety areas means that current knowledge about hazards is unsophisticated and imprecise relative to information available about the technical and economic advantages of specific production processes and different operational procedures. This research uncertainty places health and safety arguments about suspected hazards from products and processes, potential health effects and estimated social and personal costs at a substantial disadvantage relative to the more adequately documented and better substantiated arguments of business and industry that can be assembled to attest to the utility and desirability of products and processes. Uncertainty increases controversy and decreases both the likelihood of controls and the effectiveness of controls. Table 4-3 summarizes some of the problems associated with information generation, dissemination and utilization for the different potential hazards in office work.

This approach to hazard control assumes that once information has been made available to responsible parties (manufacturers, employers, workers) that sufficient motivation will be present to assure that appropriate steps will be taken to abate hazards. Historically, labor unions, public interest groups and government have concluded that it is necessary to include some level of

TABLE 4-3

Considerations Related to Generation, Dissemination and Utilization of Information Relevant to Specific Office Hazards

Potential Hazard	Considerations
Air Quality	There is currently no good information available concerning the number of people at risk. There also is a lack of information on long term low level exposures. Utilization of available information concerning ventilation is also inadequate. The information that is available has not been adequately disseminated. As a result, available control strategies are not used. Part of this is due to the lack of qualified personnel in critical positions.
Temperature/humidity	Information is readily available but does not reach those who make decisions in offices. Temperature and ventilation requirements are generally established in a piecemeal fashion by designers, architects, heating and ventilating engineers and temperature control engineers according to design specifications. Performance evaluations are not routinely performed. The major problem, therefore, lies in utilization of information.
Musculoskeletal	Information dissemination has probably exceeded information generation in this area. Most of the information has been based upon basic principles and "expert" opinions. Consequently, some recommendations have been made without adequate supporting data. In certain areas (e.g. chairs), it would appear that many are readily willing to utilize available information. More accurate and reliable information is definitely needed.
Vision	Data concerning the relationship between specific problems and potential causes is lacking. While a variety of potential causes have been identified, the relative importance of each and the efficacy of various control strategies is unclear. Much of this information is being disseminated, although not systematically, specifically to those who play a role in design. The variety of information and availability of alternative control strategies makes it difficult for end users to make proper decisions.

TABLE 4-3
(Continued)

Potential Hazard	Considerations
Stress	The biggest problem in relation to stress is the lack of willingness to utilize available information even when proven control strategies appear evident. Many of these control strategies involve considerable departures from traditional management approaches. The lack of quantifiable measures of stress outcomes presents a serious impediment. The relationship between stress-related health outcomes and potential economic incentives such as absenteeism, turnover, and productivity has not been adequately disseminated.
Noise	Control strategies are available but are often expensive. The lack of clear evidence relating irritating and distracting noise to health, well-being and productivity combined with the costs of controls provide little incentive to eliminate such noise.
Accidents	Information concerning office accidents is readily available in publications and films from a variety of organizations.
Radiation	The major problem lies in generation of information concerning risks associated with low level exposures and specifically within certain frequency ranges of the non-ionizing portion of the electromagnetic spectrum. There is also a lack of data concerning the question of adverse outcomes of pregnancy among VDT operators.

regulatory activity in the process. It is readily apparent from the discussion in previous sections that the generation of information with respect to certain hazards has been grossly inadequate, especially as it relates to the determination of risk. Some of these shortcomings include:

- typical and extreme exposure levels in office environments have not been established,
- effects of long term low-level exposure are unknown,
- number of workers exposed to specific hazards is unknown,
- inadequate demonstration of the effectiveness of proposed control technologies,
- inability to quantify the health, social and economic costs of stress, discomfort and job dissatisfaction.

In the face of uncertainty, techniques for rational calculation tend to break down. Policy makers seem to adopt strategies that avoid the worst logically possible outcomes, thereby minimizing the maximum possible loss (Mendelhoff, 1979). The position of the Canadian Task Force on pregnancy leaves for VDT operators represents a good example (see Chapter 3, Radiation section).

While the standard of proof required for scientific verification of a hypothesis is quite restrictive, that required for safeguarding rights under the law attempts to make the best decisions on the information that exists. Absolute certainly or even consensus is not required, only the opportunity for all the available evidence to be presented and a fair hearing given to all points of view (Ashford, 1976).

In fact, it is very unlikely that sufficient scientific proof will ever be available or is even possible for some health and safety questions. Particularly with regard to the potential hazard of long term, low level exposure to stressors and conditions, much scientific dispute currently exists and little clarification of the issues is likely to become available in the near future. Too little is now known or is knowable in the short run for scientific proof and definitive standards to be widely forthcoming.

Current health and safety policy is largely oriented toward abatement and control of recognized hazards through government regulation. A recognized hazard is generally considered to be a substance or condition for which the likelihood of harm has been the subject of research giving rise to reasonable suspicion (Ashford, 1979). The burden of proof required to establish this reasonable suspicion as well as that for affirming that current exposures take place at a serious level is borne by the regulatory agency. Health oriented regulatory agencies are also required by law to consider all possible adverse consequences and to minimize the regret by eliminating the most undesirable consequences rather than maximizing the expected rate of return for health benefits (Ashford, 1979).

With these preconditions in mind, there appear to be two major rationales for research. First, scientific studies need to be performed to improve the existing data base about hazards and health effects in order to facilitate understanding, control and preventive measures. A second equally important major rationale for research has more relevance for the processes of health and safety decision making. Research work is crucial to help demonstrate how pervasive problems are. This documentation function is useful to stimulate development of new technologies and control methods. Information dissemination and utilization activities concerning office hazards have been most prominent among labor unions, worker advocacy groups and the popular press. Much of this effort can be characterized as "consciousness raising" although a number of these organizations have distributed guidelines and recommendations for specific hazards. Several unions have conducted training programs or developed training materials. Many of these efforts have been directed specifically at VDT related problems.

Some manufacturers of terminals and furniture have also developed literature and in some cases sponsored research, and recently the Computer and Business Equipment Manufacturers Association (CBEMA) has initiated an information campaign and announced plan to develop an information age institute to aid in the gathering and dissemination of information related to new office technologies.

Information dissemination to related professions such as the American Society of Industrial Designers (ASID), Illuminating Engineers Society (IES), Human Factors Society, American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), National Office Products Association (NOPA), and the Business and Institutional Furniture Manufacturers Association (BIFMA) has depended primarily on industry publications and trade journals. There appears to be little organized activity in any of these organizations to disseminate information. The American Industrial Hygiene Association has conducted several training programs on VDTs and included workshops at annual meetings.

Federal government activities have included sponsorship of a conference on Occupational Health issues affecting clerical/secretarial personnel and a pilot training program on VDTs in addition to a number of publications by NIOSH researchers. NIOSH personnel have also participated in numerous conferences, seminars, and workshops. Information dissemination is largely piecemeal, however. There has been no noticeable activity with respect to office hazards within the Occupational Safety and Health Administration.

It appears that one of the major sources of information, in particular about VDTs, has been trade journals which abound with articles about ergonomic design. These publications as well as newspaper articles are usually oversimplified summarizations of the issues which serve the purpose of alerting various workers and professionals to potential problems but typically do not provide sufficient depth and detail to actually aid in hazard control. In some cases, the effort to simplify the presentation of information has led to inaccurate statements and unsupported conclusions and promises. While such information serves a purpose, it certainly does not satisfy the needs of those professionals who play such an important role in the design of offices. The importance of education has been stressed in one recent report sponsored by the National Office Products Association (NOPA, 1983).

Even in those cases in which accurate and reliable information is presented, it often proves to be of limited use to those attempting to solve practical problems. Typically, a variety of controls are described and users are left to their own resources to determine the appropriate solutions. This is often more difficult than it might appear. Consider the dilemma of an office manager attempting to choose the appropriate office chair from the selection offered by some 100 manufacturers, most of whom now offer some type of "ergonomically" designed chair. The same is true of video display terminals, workstations and glare shields. In the case of noise and lighting controls, users rely almost entirely on vendors.

Another method of disseminating information is through guidelines generated at the corporate level. Again, these efforts have concentrated primarily on the use of VDTs. Typically someone in a safety or health position is given the task of developing guidelines which will be distributed to different offices within the organization. These efforts are often of limited value due to their generality and lack of attention to local conditions, such as environment and job characteristics. These approaches often lead to poor decisions as managers adopt what appear to be standardized solutions without understanding the scope of their problems. It is impossible to determine an adequate control method if the cause of the problem has not been determined. The result of such approaches can be costly and ineffective. The employers who purchase all of the latest ergonomic furniture and improve the lighting but ignore the monotony and monitoring associated with the job may be wasting their time and money.

Another problem which can be encountered when guidelines or standards are followed blindly is employee resistance. This may occur for two reasons. The introduction of changes in the environment, workstation equipment, or methods, which interfere with the worker's performance or are inconsistent with their preferences, are unlikely to be accepted freely. The second reason for resistance may be conflicts with existing collective bargaining agreements. The unilateral imposition of job enlargement or rotation schemes may lead to demands for higher pay consistent with the higher skill level of the redesigned job. In other cases, workers who are satisfied with their current job may object to trading a portion of their job for another employee's boring job.

Market Incentives and Controls

It is often argued that forces within the market will serve to identify and control hazards. While these forces are primarily economic, in that they determine whether a business will remain profitable, they are nevertheless mediated by custom, tradition and a host of other social, cultural and attitudinal characteristics of institutions (Ashford, 1976). Within the context of market force strategies, health and safety essentially becomes a matter of cost and benefit analysis. Some of the negative forces which act within this context are described below.

(1) The direct and indirect costs of injuries, illness and job dissatisfaction, including Workers' Compensation costs, law suits, absenteeism, and labor turnover, all reduce profitability. Workers compensation costs are usually small. For example, the total cost of all workers compensation indemnity payments for 1982 for office clerical workers in Wisconsin is estimated to be $464,548 (Wisconsin, 1983). Extrapolating to the U.S. office clerical work force this would amount to $26.8 million. While this is a fairly large figure, it represents a cost of approximately $1.82 per worker. Product liability suits have become an important market force.

(2) Labor union and worker demands have traditionally played a major role in safety and health. The small percentage of organized labor within the white collar sector (8%) obviously reduces the potential influences of unions, however. Workers can, of course, refuse to work for an employer who provides poor working conditions. This may be a more powerful force than expected (in view of high unemployment rates) since most clerical jobs are low paying. If workers cannot expect to find jobs that pay higher, they may select jobs which provide better working conditions. Labor unions, on the other hand, have often been willing to accept higher wages rather than improved working conditions especially during periods of high inflation. It is interesting to note that when a group of office workers were asked if they would accept lower wage increases in return for improved working conditions 20-30% responded positively (Harris, 1980). An additional 4% of all white collar workers belong to employee associations (nearly all are professional and technical

workers). Such associations may have some influence on the market, especially on office technology issues.

(3) The purchaser can exercise market control by refusing to buy poorly designed or unsafe products. This option is often not exercised, however, either because of lack of knowledge of potential hazards or because of cost considerations.

A number of positive forces can also be identified.

(1) By establishing voluntary consensus standards and encouraging compliance, manufacturers and businesses may be able to avoid government intervention. As an example, the Business and Institutional Furniture Manufacturers Association (BIFMA) has actively participated in developing a variety of performance standards for office furniture safety. The American Society of Heating, Refrigeration and Air Conditioning Engineering (ASHRAE) has developed standards which apply to office temperatures and ventilation. The Illumination Engineering Society (IES) has participated in the development of lighting recommendations for offices. There is also an American National Standards Institute (ANSI) committee on radiation and another has recently been established through the Human Factors Society to draft a technical standard on ergonomic considerations for VDTs. The American Conference of Governmental Industrial Hygienists (ACGIH) has a long history of developing recommendations for exposures to toxic chemicals and other physical agents. There are no comparable activities which deal with issues of job stress or irritating noise. Many of these consensus standards have been adopted by reference or incorporated in federal and state safety and health standards or local building codes.

(2) One of the positive market forces which could potentially provide the strongest incentive to improve office working conditions is productivity. A variety of figures have recently been publicized which indicate that white collar productivity has not increased for a good number of years. Businesses are, therefore, very interested in methods which offer promises for increasing productivity. Office automation and improved working environments are the two most frequently proposed methods. Two recent industry sponsored studies have attempted to address the relationship between productivity and office environments. The first involved a series of studies sponsored by a furniture manufacturer (Harris, 1978, 1980; American Productivity Center, 1982)). The most recent study was conducted by the Buffalo Organization for Social and Technological Innovation (BOSTI), and was supported by grants and contracts from major corporations and government agencies. Only preliminary results from the BOSTI study have been released to date and publication of the complete results are scheduled for late in 1983. The preliminary results do suggest that job satisfaction is definitely influenced by the work environment and in some cases job performance is affected (Westinghouse, 1983).

The failure of market forces to identify and control hazards is one of the major reasons for establishing regulations (Ashford, 1980). A number of imperfections in market forces influence the effectiveness of the system. Most importantly, as with any control strategy, the market cannot control itself if it operates without adequate information. The responsibility for the development of such information becomes the burden of industry. While some large corporations have adequate resources to conduct their own research, the majority do not and thus respond by reacting, often by mimicking the technologies of competitors. While this strategy may respond as quickly as alternative approaches, it is obvious that substantial delays in the development and introduction of technology are often present. For example, the first adjustable VDT workstations were not manufactured in the U.S. until nearly four years after they were described in European reports. Table 4-4 describes user opinions concerning the responsiveness of manufacturers for a number of different office products.

While some would argue that adequate information is already available, several observations serve to demonstrate the difficulties associated with reactive approaches. As was mentioned in a previous section, some 100 different chairs are currently available to purchasers. Most are advertised as being "ergonomically designed." In view of the wide range of features and designs, one has to wonder how they all can be "ergonomically designed." Furthermore, how is the purchaser to know which are most appropriate. While the best may eventually emerge in response to the market, this could be rather ineffective strategy in light of the rather long life of a chair. In view of current costs, they will certainly not be discarded. Similar observations can be made about work tables, lighting systems, VDT screen filters, and VDT screen quality.

Information is also lacking concerning the relationship between specific health problems and their causes, the best example being eyestrain. The employer is faced with the possibility of purchasing a new, higher quality display, redoing the lighting system, purchasing filters, changing the office layout, and providing more frequent rest breaks. These choices must often be made without any assurance that the strategy adopted will actually produce the desired result. It is obvious that market demands must be supplemented by research and training.

TABLE 4-4

Manufacturer's Ability to Keep Pace With End-User Needs As Seen By the End-User

Product	Able to keep up	Somewhat able to keep up	Unable to keep up
Seating	59%	37%	4%
Space dividers	56%	37%	7%
Computer-support furniture	41%	38%	21%
Lighting	29%	53%	18%
Acoustics	22%	50%	28%
Heating and ventilation	12%	60%	28%

*Data taken from study conducted by the National Office Products Association (NOPA, 1983).

A second major disadvantage of reliance on a market system is its inability to respond to the long term effects of low level exposures, unless it is supplemented by research. Other problems associated with market forces include:

1. Market values can be based upon costs which do not consider the personal and social costs of diminished health and well-being;
2. Market forces often fail to identify indirect costs;
3. Control technologies borne purely out of market considerations may not be acceptable to workers. For example, labor unions have frequently expressed doubts about work humanization, quality of work life and similar proposals fearing that their purpose is primarily to increase productivity or diminish the strength of the union;
4. Different technologies may be less favorable to certain industries and in particular small businesses. As a result, they will respond to market forces in different ways. For example, QWL programs, the development of comprehensive manuals, job enlargement and the use of consultants are approaches which might be too costly or risky for small businesses, while unit cost strategies such as ergonomically designed furniture or rest breaks impose more equitable burdens or companies of different sizes.

Table 4-5 provides a summary of some of the relevant problems associated with market based strategies for different potential offic.

Manpower Development

The availability of adequately trained personnel is the vital link in any of the three previously described approaches to implementation of hazard

TABLE 4-5

Problems Associated with Market Based Control Strategies

Potential Hazard	Considerations
Air Quality	Most acute effects are measured in terms of discomfort and irritation. Since these symptoms may not lead to lost time, there are seldom and associated worker's compensation costs. Indirect costs associated with respiratory problems and absenteeism, reduced productivity and job dissatisfaction generally go unrecognized. Chronic disorders resulting from long term low-level exposures are difficult to associate with the work environment. The absence of direct costs coupled with potential high cost control methods provide little incentive to assess and correct potential problems.
Temperature/Humidity	Temperature and humidity problems are usually associated only with discomfort and are seldom considered by employers as potential causes of disease. Unless productivity problems can be associated with temperature or humidity problems, there is very little incentive to make potentially costly assessments and improvements.
Musculoskeletal	Musculoskeletal problems associated with poor workstation design have been recognized in recent years, especially where VDTs are used, and have led to compensible injuries and diseases. Furniture manufacturers have responded by providing better designed and adjustable products. Current problems for employers include determining which design features are important and which products are best. The utilization of additional rest breaks in jobs involving constrained postures is considered an unattractive solution due to envisaged losses in productivity.
Vision	Manufacturers of VDTs have provided better designed equipment in recent years in recognition of potential vision problems. Old equipment continues to be used, however, and is seldom replaced for this reason alone. Lighting problems have also been addressed by manufacturers and employers. Some of these problems such as screen reflections and glare affect productivity and are, therefore, more likely to be corrected. Lower lighting levels may also represent energy cost savings. Market forces may have a significant effect in this case.

TABLE 4-5
(Continued)

Potential Hazard	Considerations
Stress	Stress outcomes only rarely affect direct costs (e.g. worker's compensation claims for stress disorders). The indirect costs associated with job dissatisfaction, absenteeism and turnover must be recognized before market forces will take over. Currently, only the largest employers are involved in stress reduction programs. Stress management programs are the most popular.
Noise	Since most sources of noise in offices do not constitute risks to hearing, there are no direct costs. Noise (especially conversation) which effects productivity is often recognized as a problem by employers. Costs associated with controlling noise are potentially high in old open-plan and traditional bull-pen offices and often delay implementation.
Accidents	The total direct costs of accidents in offices is relatively low. Market forces can be expected to have an impact only when a serious accident occurs.
Radiation	While there are methods available which could potentially reduce radiation emissions (including shielding and new technologies such as flat panel displays), the increased costs are not considered justifiable by manufacturers in view of industry and government positions that current radiation emissions do not constitute a hazard.

control strategies. The generation, dissemination and utilization of information all require adequately trained personnel. Regulatory activities depend upon inspectors; and for market forces to operate, hazards must be identified and abated by capable individuals. Obviously, both employees and employers suffer when manpower shortages exist. Unfortunately, there has always been such a shortage, even in the most basic areas of safety and industrial hygiene. For two reasons these deficiencies become even more obvious when office safety and health issues are considered. First, existing personnel are heavily concentrated in manufacturing, construction, and mining industries with interests focused largely on blue-collar workers. Adding office workers to the pool of workers requiring attention nearly doubles the coverage required, further diluting an already deficient supply. Pulling existing manpower away from high hazard industries will be difficult. Secondly, even if it were possible to refocus the attention of safety and health personnel on office hazards, many of these individuals are not adequately prepared to deal with the unique issues raised by office workers.

The same types of personnel are required regardless of occupation or industry, and include: safety professionals, industrial hygienists, medical professionals, ergonomists, industrial psychologists, designers, and engineers. Furthermore, meeting these manpower requirements depend upon an adequate supply of educators supported by sufficient resources and research.

The need for trained professionals will continue to exist among employers, government agencies (both regulatory and consulting), consulting services, product manufacturers, and universities. While a number of universities now offer training in occupational safety and health for professionals, only a few have done much in the area of office health and safety. University research and training depend almost entirely upon government or private funding. Government funding has become more and more limited in recent years and funding for training is currently limited almost entirely to the 15 Educational Resource Centers established by NIOSH.

Most office workers start at a considerable disadvantage since few enjoy the luxury of even having a bona fide safety director. Generally, only those who work in offices supporting industrial, construction, and possibly service industries, have access to safety professionals or industrial hygienists. A few of the larger information industries employ full-time safety and health professionals and these individuals usually reside in corporate offices with only limited contact with the day-to-day problems in the office. As is the case in most small industries, safety and health responsibilities are typically assigned to personnel departments. Outside resources must be relied on extensively in dealing with ergonomics, psychological, job design and medical problems.

It is evident, therefore, that if employers begin to actively deal with occupational health and safety problems, a large proportion of the manpower need will be for consultants in all fields. Most offices will not be able to economically justify employing full-time personnel below the corporate or central office level. This might only be feasible be if there were actually specialists in office safety and health available (trained in all aspects of safety and health). Qualified consultants have become more available in recent years as a variety of management consulting services have anticipated this need and expanded their services. In fact, it may be true at the present time that the supply exceeds the demand. While state government agencies have been providing occupational safety and health assistance to employers, most are not currently prepared to offer the range of services essential in office environments, since most only employ traditional safety professionals and industrial hygienists. In any case, it is doubtful that employers will utilize available consulting services extensively, but will choose to deal with problems by using their own resources. One of the most viable methods of dealing with office health and safety may, therefore, be to increase the expertise of currently utilized manpower and services. Some of these resources include: heating, ventilating and air conditioning engineers, facilities managers, industrial engineers, personnel managers, and data processing managers within the company; and interior designers, engineers, architects, furniture manufacturers and dealers. Table 4-6 lists the type of manpower and resources which could be utilized to deal with different safety and health problems as well as some of the current deficiencies. Increasing the expertise of available manpower resources would depend upon the availability of training for these professionals and services. Numerous professional organizations and trade associations already offer safety and health related services to members. Table 4-7 lists some of these groups and the services currently offered. The extension of some of these services may present a very effective means of reaching a wide variety of individuals who could have a significant impact upon office working conditions.

Another internal source of manpower which has proven to be a viable entity in other industries is the safety and health committees. Such committees are, however, rare in office environments, largely due to the rather low level of unionization within the industry. Union staff and safety committee members who have been able to receive training through their unions or universities have often been able to assist employers in dealing with safety and health problems. Government funding of employee training has also been almost entirely eliminated in recent years, however. Quality of working life committees such as those negotiated by the Communications Workers of America and

TABLE 4-6

Manpower Resources and Related Problems

Potential Hazard	Internal	External	Current Deficiencies
ERGONOMICS (Musculoskeletal, visual, fatigue problems)	industrial engineers facilities managers worker groups	ergonomists physicians nurses industrial engineers lighting engineers product designers office products dealers space planners architects interior designers	- Ergonomists and health professionals are seldom available internally. There is also a shortage of outside consultants. - Industrial engineers and facilities managers lack training in ergonomics. - Lighting engineers, space planners, architects and interior designers lack training in ergonomics. Need training to balance human needs against cost, efficiency, and esthetic requirements. - Manufacturers of office equipment and furniture have improved ergonomic features but need better and more consistent guidelines. - Office products dealers need training in ergonomics. - Worker groups and unions are not widespread.
INDUSTRIAL HYGIENE (air quality, temperature, ventilation, humidity, noise, radiation)	industrial hygienists maintenance personnel engineers	industrial hygienists heating, ventilating air conditioning engineers	- Industrial hygienists are usually available through outside private groups and government agencies and are rarely utilized by employers. - Engineering and maintenance personnel need training and redirection to address employee health problems. - HVAC designers and engineers need training related to worker health and comfort.

TABLE 4-6
(Continued)

Potential Hazard	Internal	External	Current Deficiencies
STRESS	industrial enginneers QWL committees	psychologists job design experts QWL experts stress management experts industrial engineers	- Stress management, humanization, and job design consultants are available but not extensively utilized. - Industrial engineering emphasis is heavily oriented toward productivity rather than employee well-being. - QWL approaches are usually employed only in large companies.
SAFETY	safety engineers safety and health committees	safety engineers	- Few offices currently have access to safety engineers. Safety and health committees are rare in offices.

TABLE 4-7

Professional Society and Trade Association Services†

Organization	Services and Activities			
	A	B	C	D
American Academy of Safety Education	X		X	
American Association of Industrial Nurses	X	X		
American Conference of Governmental Industrial Hygienists	X	X		X
American Industrial Hygiene Association	X	X		X
American Insurance Association		X		
American Institute of Architects		X		
American Management Association	X			
American Medical Association	X	X		
American National Standards Institute		X	X	
American Public Health Association	X	X		
American Society of Heating, Refrigerating, and Air Conditioning Engineers	X	X	X	
American Society of Safety Engineers		X	X	
Business and Institutional Furniture Manufacturers Association		X	X	X
Computer and Business Equipment Manufacturers Association		X		
Human Factors Society	X	X		
Illuminating Engineering Society	X	X	X	
Industrial Medical Association		X		
Institute of Business Designers	X	X		
National Council on Radiation Protection and Measurements	X		X	
National Office Products Association	X	X	X	X
National Safety Council	X	X	X	X

†This list is not intended to be exhaustive, but represents the range of possible organizations with potential impact on office health and safety. Most of these organizations have state and local affiliates which are especially active in training.

A - Training - includes seminars, tutorials and courses
B - Information - includes responses to inquiries and publications
C - Research - includes sponsoring and conduction research
D - Advisory - includes referrals, consulting services, or information services

Services listed are only those known and may be incomplete. A primary source for this information was Peck (1974).

AT&T also could serve as a means of dealing with office working conditions. While expertise is often needed to evaluate and abate hazards, it is a well recognized fact that employee involvement in problem solving is an important and helpful technique, which can often reduce the impact of professional manpower shortages.

Methods of Overcoming Control Strategy Obstacles

For each of the alternative strategies, a variety of obstacles have been identified. Some are unique to specific methods while others appear to be universal. The most evident obstacle to the development of any approach to controlling office hazards is the absence of adequate information concerning the nature and prevalence of hazards and the effectiveness of control technologies. While a variety of control technologies have been proposed, they are based largely on "expert" opinion rather than scientific data. The most pressing need is for the development of a comprehensive research program. While competitive industries will continue to conduct some of this research, a major burden will obviously fall upon federal agencies, most notably the National Institute for Occupational Safety and Health. The types of research which have been conducted by NIOSH in recent years have been described in Chapter 3. The total projected funds for research on office related hazards in FY 84 are, however, less than $300,000. This amounts to less than one cent per office worker.

The types of research efforts considered necessary fall into several categories:

1. Broad based epidemiological studies are necessary to determine the prevalence of problems. Studies designed to determine the number of

individuals actually exposed to office hazards, typical exposure levels and extreme exposure levels must be carried out. Lacking this type of information, it is virtually impossible to establish appropriate policies for dealing with problems.

2. Practical demonstrations of the relationships between specific risk factors and measurable outcomes must be conducted. With the exception of low-level long-term exposures, such research could provide valuable insights concerning the effectiveness of alternative control technologies. Since many of the problems encountered by office workers involve subjective symptoms (e.g. eyestrain, muscular aches and pains, temperature discomfort, irritating noise, tension, etc.), they lend themselves to rather straight-forward, experimental designs in both laboratory and in field settings since measures of these outcomes can be evaluated in before and after situations when adequate and careful attention is given to control of extraneous factors.

3. While of lower priority, studies of the extent of utilization of various control technologies would be helpful in making policy decisions related to different strategies.

4. Another area of research which could prove fruitful relates to the establishment of quantifiable outcome measures. For example, establishing the relationship between working conditions and measures such as absenteeism and turnover which have directly associated costs could provide a powerful incentive for employers to abate hazards.

5. In view of the widespread interest in productivity in the white collar sector, studies which serve to further substantiate the

relationship between productivity and health and well-being could also provide an incentive to improving working conditions.

6. Research concerning the potential effects of long-term low-level exposures to physical agents and psychological stressors should be carried out on a continuing basis.

The second method of overcoming the obstacles associated with different control strategies involves information dissemination. There is an obvious need to develop the expertise of those responsible for safety and health. This includes employers, manufacturers, vendors, professionals and employees. Models for providing such education already exist, dating back to the years immediately following implementation of the Occupational Safety and Health Act (i.e. training by NIOSH or grants and contracts to labor organizations, labor education programs, professional organizations, and industry). Such an approach could serve to increase the accuracy and usefulness of communicated information. In view of the obvious demand for such information, it would appear that trainees would be willing to bear a substantial portion of the cost. Along with this training, it would also be beneficial to establish a number of resource centers throughout the country which could aid in the collection and dissemination of information, or as an alternative, provide assurance that present NIOSH Educational Resource Centers are adequately addressing the needs of office workers.

A third method of overcoming obstacles would involve the provision of consultative service to small businesses who lack the resources and technical expertise to effectively evaluate and abate hazards. Many state agencies already participate in consultative programs funded by the federal government, although few have done much in the area of office hazards.

Finally, the possibility of providing incentives to manufacturers and businesses deserves consideration. Precedents already exist for some of the incentives. Examples include:

- tax incentives for health and safety research and development,
- accelerated depreciation for new, well-designed equipment,
- low interest loans for work environment improvements.

Incentives might also be used to increase the attractiveness of entering health related fields by providing low interest loans or stipends to students.

Summary

Public concern has resulted in an increased level of consciousness of potential health and safety hazards in offices. It is readily apparent that many of these concerns are well founded and that the level of concern is not about to subside. Many of the hazards faced by office workers are amenable to rather straight forward abatement techniques. In addition, a sufficient number of questions have been raised about long-term low-level exposure effects and potential adverse effects of new technologies to justify concerted research activities. It is evident that government has a role to play in the development of strategies aimed at improving the working conditions of office workers. One of the ways government has traditionally dealt with safety and health hazards is through regulations and enforcement activities. When it can be shown that existing standards are violated, these enforcement activities will come into play. As has been pointed out, many of the problems faced by office workers are not covered by any present standards. The record of the federal government in passing new standards; and the unique nature of many potential office hazards as well as the nature of adverse health effects experienced, would appear to indicate that it is unlikely that any such action will occur at the national level. It is difficult to predict what will happen at the state level.

The federal government could still play an important role outside of regulatory activities. This role would include carrying out and funding research, training programs, and consultative services. Government could also encourage safety and health activities by providing financial incentives. Since such efforts have been minimal in all areas of health and safety in recent years, it is unlikely that any programmatic approaches dealing exclusively with office hazards will be possible. It will, therefore, be necessary to consider office hazards within the context of increased activity in all areas of safety and health.

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